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Chromatin-reduction and Tetrad-formation in Pteridophytes.

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(Plates 295, 296.)

From the time when Van Beneden, in 1883, found that mature reproductive cells have only half as many chromosomes as the ordinary somatic cells, until the present time, cytologists have endeavored to explain the meaning of this reduction and to show how it takes place. These efforts have not as yet been attended with complete success.

One of the most widely known theories as to the meaning of reduction is that of Weismann who accepted the earlier conception of Roux (1883) as to the significance of mitosis and built upon it an elaborate theory of development. In this he predicted that a form of mitosis would be found in the maturation of the reproductive elements "in which the primary equatorial loops are not split longitudinally" (p. 371) and "by means of which each daughter nucleus receives only half the number of ancestral germ-plasms possessed by the mother nucleus" (p. 375).

Weismann's prediction has been confirmed by recent observations on the copepod crustacea, and it is now known that in this group of animals at least, the chromosomes of a maturing cell undergo a transverse division, giving reduction in the Weismann sense. This process of reduction, wherever definitely made out, is invariably preceded by an arrangement of the chromatin into four-parted chromosomes, to which the name "*Vierergruppen*" or "tetrads" has been given. These tetrads are always half as nu-

merous as the chromosomes of the somatic cells and often differ widely from them both in shape and size.

The entire question of reduction rests upon the manner of tetrad-formation, but unfortunately, observers are diametrically opposed in their descriptions of the process. On the one hand it has been shown beyond question, that in some cases (the copepod crustacea) two of the four parts of the tetrad are formed by longitudinal division of the spireme-segment, while the other two arise by transverse division. In such cases two successive mitoses divide the tetrads, first into two dyads and second into single elements. By these two divisions the resultant reproductive cell receives one-fourth of each of the original tetrads. On the other hand, in another case, *Ascaris megalocephala*, where the facts also seem to be beyond contradiction, Brauer has shown that the tetrads arise by double longitudinal division of the spireme-segments and that no transverse division takes place. In this case reduction is purely quantitative and not qualitative.

The botanists Guignard (1891) and Strasburger (1888) have maintained that in plants also, a reduction in the Weismann sense does not take place. Neither Guignard nor Strasburger found tetrads. They described the spireme as breaking up into half the normal number of chromosomes which undergo simple longitudinal division at each successive mitosis.

It would be remarkable if a process so general in animal cells as the formation of tetrads should not be found in plant cells, and with the hope of finding some evidence of this in plants I undertook the study of reduction in the group of Pteridophytes, the results of which are given in the following section.

I. Observations.

Guignard and Strasburger found that in *Lilium* and in *Allium* the pollen-grain after reduction, undergoes subsequent mitoses, in each of which the same reduced number of chromosomes is retained. This led Overton (1892) to suggest that reduction in the higher cryptogams, where sexual and asexual generations alternate, might take place as far back as the formation of the spore. He also suggested that all of the cells of the sexual generation might have the reduced number of chromosomes, and in 1893 he strength-

ened his position by showing that the cells of the endosperm in the Gymnosperm *Ceratozamia*, divide with the reduced number. But it was Strasburger (1894) who proved it, beyond doubt, by showing that in the fern *Osmunda* all the cells of the prothallus have the reduced number of chromosomes; in other words that all cells derived from the spore have half as many chromosomes as the cells of the asexual generation. Reduction in ferns, therefore, takes place during the formation of the spore and here, if anywhere, we must look for the tetrads.

A. Material and Fixation.—Two fern species (*Pteris tremula* and *Adiantum cuneatum*) were selected, which were found in a fernery in October, to be in various stages of spore-formation. The pinnae were removed and cut into small pieces before fixation. The fixing agents used were 1, Herman's platino-aceto-osmic mixture; 2, Von Rath's fluid; 3, corrosive sublimate; 4, sublimate-acetic; and 5, picro-acetic. The best results were obtained with 1, 3 and 4. The pieces were imbedded in paraffine and cut horizontally in sections about 4 to 5 μ thick. The stains used were Heidenhain's haematoxylin, either alone or with orange G or Congo red as counter stains in the majority of preparations, although Flemming's triple stain gave good results.

B. Terminology.—In animals three periods are recognized in the development of the reproductive cells (O. Hertwig). 1. A "division period," during which the primordial germ cells ("oögonia" and "spermatogonia") increase by ordinary mitoses; 2, a "growth-period," during which the primordial germ cells enlarge and during which tetrads are formed. These cells are known as "primary oöcytes" and "primary spermatocytes," and 3, the "maturation-period," during which the nuclei with tetrads are divided by mitosis into nuclei with dyads ("secondary oöcytes" and "secondary spermatocytes"). These are again divided to form eggs or spermatids.

As regards the periods of maturation it can now be shown that both male and female cells in many animals, and reproductive cells in some plants (Pteridophytes), conform to the same type. It is well known that in spore formation of *Pteris*, the single primordial cell ultimately gives rise to sixty-four spores. It is also known that there are sixteen so-called "spore-mother-cells" in each spor-

angium, and that from these sixteen cells the final spores are formed. The stage between the first spore cell and the sixteen cells is directly comparable with the "division-period" in animal maturation. The sixteen-cell stage (see next page) is the stage of enlargement and of tetrad-formation and corresponds with the "growth-period." Finally the "maturation-period" is recognized by the two consecutive divisions of the sixteen cells to form the sixty-four spores.

As the maturation phenomena are so closely parallel in plants and animals, it would be of advantage to have the corresponding cells designated by analogous names. In some cases the present botanical names are unwieldy and inappropriate. The "spore-mother-cell" as a designation for the cells of the sixteen-cell stage is incorrect as well as clumsy; for, if we consider the nuclei alone, these cells do not give rise to the spores, but to the "mother-cells" of the spores, and are therefore the "grandmother-cells" of the spores. I propose, therefore, to use the term "primary sporocyte" for the cells of the sixteen-cell stage, and "secondary sporocyte" for cells of the thirty-two-cell stage. These terms are directly analogous to "primary" and "secondary" "oöcyte," and "spermatocyte" in animal cells. The term "sporogonium," which in this connection would be analogous to the term "oögonium" or "spermatogonium" is, unfortunately, already used in a different sense in botanical nomenclature and I shall therefore designate the first eight cells in spore formation as "archesporial cells" in accordance with botanical usage.

C. Observations.

It is beyond the scope of this paper to describe in detail the formation of the sporangium, with its annulus and tapetum, or to describe the degeneration of the tapetal cells. Nor is it necessary to give aminute account of the mitoses leading up to the formation of the sixteen sporocytes. They all agree with the division of the "archesporium" and the number of the chromosomes apparently remains the same, although they are so numerous that it is impossible to give the absolute number. From careful counting in several cases, I estimate the number to be between one hundred and twenty and one hundred and thirty.

The unicellular archesporium, which is destined to give rise to

all the spores of the sporangium, can be readily distinguished from the surrounding somatic cells. It is larger, and the chromatin of the nucleus stains much more deeply than that of the other cells. The chromosomes are large and distinctly looped, and in the metaphase of karyokinesis they are split by a longitudinal division (Fig. 17). After each division the daughter-nuclei pass into the resting stage, during which the cell-walls are completely formed and each daughter-cell becomes completely separated. The resting stages are comparatively long and the division stages short.

1. *The growth-period.*

After the sixteen primary sporocytes are formed the nuclei pass as usual into the resting stage (Fig. 1). The nuclei are at first comparatively small (10.3 μ in diameter), the chromatin-reticulum does not stain intensely, and there are usually from one to three or more nucleoli in each. Meantime the tapetal cells degenerate, giving room for growth of the reproductive elements. This growth must begin very soon for the cells in the resting stage (Fig. 1) are not frequently found. When fully grown, the nuclei measure about 14.5 μ in diameter, an increase of nearly 50 per cent. During this enlargement the chromatin reticulum is converted into a delicate moniliform spireme. This is a single thread of chromatin, very much coiled and interwoven and at first distributed evenly throughout the nucleus (Fig. 2). From this condition of extreme delicacy and expansion the chromatin soon passes into a stage of greater localization and the spireme becomes thicker. Evidence of the beginning of concentration can be seen in Fig. 2 an early stage, where the nucleolus has not disappeared. In a later stage, to which Farmer has given the name "Synapsis," the meshes are drawn towards one side of the nucleus into a much more compact chromatin mass (Fig. 3). This mass next becomes loosened and the filaments more or less isolated. In exceptionally favorable preparations the spireme in this stage is seen to be double (Fig. 3 x).

The concentration of the chromatin at the same time with the thickening of the spireme seems to indicate a coalescence and union of the formerly distinct granules of chromatin in the delicate moniliform spireme.

2. *Period of tetrad formation; pseudo-reduction.*

In the case of animals when the spireme thread breaks up into segments destined to form tetrads, the number of these segments is, in general, half the number of chromosomes in the somatic cells. There is a reduction in number of chromatin masses, but the nucleus still contains all the chromatin it held at first, so that actual reduction has not yet taken place. Rückert (1894) has accordingly proposed the expressive term "pseudo-reduction" for this preliminary halving of the number of chromosomes.

Pteris forms no exception to this rule. The double spireme breaks up into short and well defined chromatin segments (Fig. 5 a) each of which gives rise to a tetrad. The number of these segments is difficult to determine; in several cases I counted about sixty. This is about half of the number in somatic cells where, as nearly as I can make out, there are between one hundred and twenty and one hundred and thirty chromosomes. It is an interesting fact that the process of tetrad formation is subject to some variation and does not, apparently, conform exclusively to any one type. This conclusion is based upon the following facts. The spireme segments are, from the beginning, invariably double (Fig. 5 a). The same nuclei contain various modifications of the double segment. Some of them are split in the center while the ends remain connected, giving rise to ring forms (Figs. 4, 5, 19 c). In some there is no separation at all, in others the ends separate, giving rise to "cross" forms (Fig. 6 l and Fig. 19 a) and in still others one half the segment may slide along on the other half till the ends are no longer contiguous (Fig. 6 d and e). There may be still further modifications of the double segment in the same nucleus (Fig. 5 x). In none of the nuclei which I have examined does any of these types predominate; and from their various and diverse shapes it is impossible to regard them as developmental stages of a single type. I am forced, therefore, to the conclusion that, in these ferns, tetrads may be formed in a variety of ways. The various methods can be grouped into three types, which I will describe separately as (a) the "ring type;" (b) the "rod type;" and (c) the "cross type."

a. The "ring type." Almost every primary sporocyte contains from one to several (8 or 9) ring forms in different stages. In

some cases the chromatin portion is thin and the opening comparatively large (Fig. 4 c, 5 c, 19 c). In no case is the ring thin and delicate as in *Heterocope robusta* (Rückert, 1893, Fig. 23). The ring stage begins with a lateral bulging of the two halves of the spireme segment (Fig. 6 i); this is followed by the appearance of a furrow at the center. This furrow enlarges until it forms a circular space, and, the ends of the segment remaining attached, the chromatin forms a closed ring (Fig. 19 c). The chromatin then begins to accumulate in four parts, each half of the originally double spireme forming two (Figs. 6 J, 19 c and 20 c). These parts become more and more distinct and individualized; more compact and tightly packed together, until finally the tetrad is completed (Fig. 7). The tetrad is, therefore, derived first, by a longitudinal splitting of the spireme segment, and second, by the transverse splitting of the two halves.

b. The "rod type." The tetrad begins as before with the short and somewhat thickened double spireme-segment, but here no separation of the two parts of the segment takes place (Fig. 5 a). The chromatin segregates at the two ends in four swellings (Fig. 6 b). These swellings enlarge, become more definite and the segments become shorter by the gradual drawing together of the ends. The ends finally round out and tetrads are formed by what would seem to be the simplest method possible.

There are some modifications of this type. In some cases the two halves of the spireme segment slide along on each other until, in an extreme case, the opposite ends may become contiguous (Fig. 6 d, e). The resultant tetrad does not differ essentially from one formed in the simpler manner. There is the same segregation of chromatin at the four ends, the same shortening of the segment and finally the same end result, although at first the tetrad is somewhat distorted. In the rod type, therefore, the tetrad originates first by a longitudinal division of the spireme, and second, by transverse division of the halves and is equivalent in all respects to the tetrad of the "ring type."

c. The "cross type." In this type the halves of the double spireme segment, instead of separating in the centre as in the "ring type," or of remaining parallel to each other as in the "rod type," become separate at the two ends but remain attached to

each other in the centre. (Fig. 6 a, l., etc.) These ends separate farther and farther until each half segment forms a loop which lies in contact with the other half segment only at the center of the convex side (Fig. 6 c). It is the opposite of the ring type. In some cases the segregation of the chromatin begins at an early period (Fig. 6 a), and, as separation continues, the segregation becomes more marked, until finally there are four distinct swellings lying at right angles to each other (Fig. 6 c, 19 a). The loops meantime become shorter and shorter, until finally the four parts of the chromosome are brought together, and a tetrad is formed similar in all respects to those of the "ring" and "rod" types (Fig. 6 k).

Like the "rod type," the "cross type" shows some modifications. After the ends have begun to diverge as in the normal cross type, one of the loops may swing around through an angle of 90 degrees on the point of attachment as a pivot (Fig. 6 f). It thus comes to lie in a plane at right angles to its original position. Segregation of the chromatin gives rise to the four parts of the chromosome as before. Various other modifications of this type are found (Fig. 5 x), but in all of them the result is the same. Here, therefore, as in the other types the tetrad originates first by a longitudinal division of the spireme-segment and second by transverse division of the halves.

3. *Period of Reduction.*

It is in this period of spore development that reduction of the chromosomes actually takes place. It begins with the arrangement of the mature tetrads into the nuclear plate of the primary sporocyte spindle. Before this arrangement the tetrads are distributed throughout the nucleus (Fig. 7). The nuclear membrane disappears, and after this, for the first time, it can be clearly seen that the nuclear space is filled with almost parallel spindle fibres (Fig. 8). The latter at this stage could not be traced to definite points at the poles. The tetrads lie in various positions on the spindle fibres (Fig. 9), but they gradually collect at the equator of the spindle. The migration towards the equator of the spindle is clearly shown in Fig. 10 for *Pteris* and Fig. 20 for *Adiantum*, while Fig. 11 shows the completion of the spindle in *Pteris* and the definite formation of the nuclear plate. In this stage the tetrads

are closely packed, and are so numerous that counting is impossible. In the early stages, however (Figs. 8 and 10), it can be seen that the number is about sixty.

The compact arrangement of the tetrads in the nuclear plate leaves no chance for orientation. It is impossible, therefore, to tell from this division whether the tetrad divides through the line of original cleavage, or through the secondarily acquired transverse cleavage. In other words, it is impossible to tell whether the division of the primary sporocyte is a reducing or an equation division. There is, however, good reason to regard this as an equation division, and the division of the secondary sporocyte as transverse, and, therefore, as a reducing division. The second mitosis follows closely on the first, but in the short interval the two parts of each dyad, which at first appear like two small balls closely pressed together (Figs. 12 and 21), now become drawn out in the direction of their common axis, which is probably the original longitudinal axis of the spireme-segment (Figs. 13 and 14). It is immaterial in the final spore cells whether the first or the second division is a reducing division in the Weismann sense. That one of them must be is shown by the method of tetrad formation; but, from the manner in which the dyads elongate, the probability is certainly strong that reduction is effected by the second mitosis. The change in shape of the chromosomes in the secondary sporocyte-spindle makes the general appearance of the nuclear plate conform more nearly with that of the somatic cells (cf. Figs. 13 and 18), although they are fundamentally different.

4. *The spore.*

The cylindrical shape of the daughter chromosomes as they come from the division of the dyads in the secondary sporocytes is retained until late in the anaphase (Fig. 14). The resulting four daughter-nuclei lie freely in a single cell which, until the cell-plates are formed, is a syncytium. In the division of multinuclear cells it has been frequently noted that the nuclei are connected by spindle fibres. This occurs in ferns, and long after division, and even as late as the telophase after the cell-plates are formed and the nuclei have gone into the resting stage, fibres can still be seen connecting each nucleus with all the others (Figs. 14 and 15). While the cell-plates are forming, the chromosomes gradually dis-

integrate and pass into the reticulum although their outlines can be dimly made out even after the reticulum is well formed and the nucleoli have reappeared (Fig. 16).

5. *The centrosome.*

It is extremely difficult to stain, and correspondingly hard to find the centrosomes in this material; even at the spindle-poles its identification is not easy. I was able, however, to make it out in two different stages (Figs. 11, 12 and 13). One of these was in the mitosis of the primary sporocyte, the other in that of the secondary sporocyte. In the first of these the centrosome at the spindle-poles was double (Figs. 11 and 12), in the second it was single (Fig. 13).

II. Tetrad-formation.

In cases where reduction in the Weismann sense is actually known to take place, there have been wide variations in the accounts of the process. It was first described by a former pupil of Weismann's, Ishikawa, who did not find tetrads and who held that reduction in the copepod *Diaptomus* is accomplished by the separation of entire chromosomes. This result is entirely contradictory to the more recent results obtained by the subsequent study of *Diaptomus* and other copepods.

Vom Rath, apparently the first to correctly interpret the formation of tetrads, gave a different account of reduction in the insect *Gryllotalpa*. He found that the spireme is double before it breaks up and that there are half as many of the double segments as there are chromosomes in the somatic cells. The halves of the double segment separate, except at the ends, and a ring is formed. Later the tetrads arise by concentration of the chromatin at four points of the ring, a method by which the four parts of the tetrad originate by longitudinal division represented by the original division of the spireme, and by a transverse division.

Häcker gave still another description of tetrad-formation in *Cyclops strenuus*. His details have been denied by Rückert, who, however, accepted the general results and agreed with him that the tetrad is formed as in *Gryllotalpa* by a longitudinal and a transverse division of the original spireme segments. Rückert (1893 and 1894) has found two modes of tetrad formation, each

giving, however, the same results, viz.: the formation of tetrads by a primary longitudinal and a secondary transverse division of the spireme. The first method (*Cyclops*, *Canthocamptus*) agrees almost exactly with what I have here described as the "rod type." The spireme is divided longitudinally before segmentation into half the normal number of chromosomes. The chromatin then begins to collect into a much thicker double rod; the rod then divides transversely and the tetrad is formed by longitudinal and transverse division. The other method described by Rückert takes place in *Heterocope* and *Diaptomus* and agrees very closely with what I have described as the "ring type." The double spireme breaks as before, but the double segment, instead of remaining contiguous throughout, becomes separated in the middle, while the ends alone remain in contact. A ring is thus formed and tetrads arise later by two divisions, one through the diameter of original cleavage, the other at right angles to this line.

Enough has been given in this account to show that certain methods tetrad-formation are characteristic of certain species of animals. Up to the present time it has always been found that the tetrads in a single nucleus are formed by one method, either by the "rod type" or by the "ring type" alone. My observations on the fern, however, show that tetrads in the same nucleus may be formed by both methods or even by a third. From these facts the conclusion seems inevitable that all the types of tetrad-formation mentioned above are merely modifications of the same process and have no significance in themselves so long as a common result is obtained.

It seems remarkable that such obvious structures as tetrads should have been hitherto overlooked in the plant reproductive cells. Many observers have noticed that the mitosis in the sporocyte differs from that of all other cells, whether somatic or archesporial. This difference was early recognized by Guignard and Strasburger. Overton and Belajeff also were struck by the peculiar shape and appearance of the chromosomes in this mitosis; the latter especially described them as agreeing in all particulars with Flemming's account of heterotypical mitosis. Finally Farmer (1895), in speaking of the pollen-mother-cell of *Lilium Martagon*, refers to

structures which can be explained only as early stages in tetrad formation: "Die Form der Chromosomen ist sehr unregelmässig, zuweilen erscheinen sie als Bänder, oft als Ringe mit einer oder zwei Protuberanzen, letzteres tritt namentlich in etwas späteren Stadien auf. Ich habe viele Zeit geopfert, mit dem Versuch zu einer festen Entscheidung darüber zu kommen, ob die Ringähnliche Form wirklich primitiv vorhanden oder einer inneren Spaltung zuzuschreiben ist, die das Chromosom noch nicht vollständig getheilt hat. Ich neige stark zu letzterer Annahme und betrachte desshald die Ringform, wo sie verkommt als ein frühes Anzeichen der Langstheilung des Chromosoms" (p. 58). Again he says: "Es braucht kaum bemerkt zu werden, dass diese heterotype Form der Mitose auf die Pollenmutterzellentheilungen sich beschränkt und sich weder in den vegetativen, noch in den früheren Archesporialen Theilungen derselben Pflanze findet" (p. 64). And finally: "Was die zweite Kerntheilung in Pollenmutterkorn betrifft, so zeigt sie gar nichts von den eigenthümlichen (heterotypischen) Vorgänge, welche die erste Mitose characterisiren, sie weicht nur durch die behaltene reducirte Chromosomenzahl von einer vegetativen oder eine frühen Archesporialen Kerntheilung ab. Es ist daher wahrscheinlich, dass die der ersten Theilung besonderen eigenthumlichkeiten mit der plötzlichen Chromosomenzahlveränderung in einer directen und causalen Beziehung stehen" (p. 67).

The still later work of Miss Sargant ('95), on the chromosome of the pollen-mother-cell of *Lilium Martagon*, shows that a transverse division of the chromosomes probably takes place. She does not mention the formation of rings which were described by Farmer as preceding the nuclear plate stage, nor does she mention tetrads. But as Wilson first pointed out ('96 p. 197), her description of the dividing chromosomes give strong reason to believe that these structures are to be interpreted as tetrads.

The fact that so many observers have described phases which suggest more or less clearly the formation of tetrads in different groups of plants, together with my own observations on the ferns, render it probable that further study will show the reduction of chromosomes through tetrad formation to be a phenomenon of as wide occurrence among plants as it is already known to be among animals.

Summary.

1. The spore maturation in Pteridophytes agrees step by step with the maturation of sexual cells in animals.

2. As in animal maturation, the process of spore-formation can be divided into three periods of division, growth and maturation. The *division-period* is the interval between the archesporium and the sixteen-cell stage of the sporangium. The *growth-period* is the interval during which the sixteen cells enlarge and tetrads are formed. The *maturation-period* includes the two successive divisions of the nuclei in the sixteen-cell stage, and the formation of the spores.

3. Different terms are used to designate the cells in the different stages of maturation. Those of the "division-period" are known as the "*archesporial cells*." Those of the "growth-period" have hitherto been known as the "spore-mother-cells." The term "spore-mother-cell" is, however, inaccurate and clumsy, and I suggest the term *primary sporocyte* in its place, also *secondary sporocyte* for the daughter-cells of the primary sporocyte. These are the mother-cells of the spores and by their subsequent division the sixty-four spores are formed.

4. The "growth-period" is the most important stage in maturation. It begins with a distinct enlargement of the cell. The chromatin then forms a delicate moniliform spireme before the nucleolus has disappeared. A much thicker spireme is subsequently formed from the moniliform thread. The thickened spireme then splits longitudinally. It next breaks up into half as many double spireme-segments as there are chromosomes in the somatic cells; each of these double elements forms a tetrad.

5. Three types of tetrad-formation are found in each nucleus. These may be called the "rod type," the "ring type" and the "cross type." In the first type the halves of the double spireme segment are completely separated; in the second, the halves become separated in the center but remain connected at the ends; in the third type the halves become separated at the ends but remain connected at the centre.

6. In all three types the tetrads are finally formed by a transverse division of the halves of the double spireme-segment, giving reduction in the Weismann sense.

7. These methods of tetrad-formation have no significance in themselves so long as a common result is obtained. They may be considered as modifications of the same process.

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Description of Plates 295, 296.

Figures 1–18 are stages in *Pteris*; figures 19–21 are *Adiantum*; all figures are drawn with a Zeiss Camera lucida.

Fig. 1. Early sporocytes in the resting stage subsequent to the last division of the archesporial cells. × 1800.

Fig. 2. Primary sporocyte after growth. Chromatin arranged in a delicate, single, moniliform spireme, nucleolus persistent. × 1800.

Fig. 3. Primary sporocyte with thickened and concentrated spireme. The end (x) is double. × 1800.

Fig. 4. Primary sporocyte showing different stages in tetrad formation. C-ring forms. × 1800.

Fig. 5. Primary sporocyte; portion of nucleus showing stages in tetrad formation. A-double spireme segment; C-ring forms; X-divergent forms. × 2300.

Fig. 6. Various types of tetrad formation; A, B, C, F, G, H, K, L, show the "cross type," D and E the "rod type," I and J the "ring type." × 3600.

Fig. 7. Primary sporocyte with finished tetrads. × 1800.

Fig. 8. Primary sporocyte showing spindle fibres, loss of nuclear membrane, and distribution of the tetrads. × 2300.

Fig. 9. Primary sporocyte section showing fewer tetrads and the arrangement on the spindle fibres. × 2300.

Fig. 10. Primary sporocyte, a prophase showing concentration of the tetrads into the nuclear plate. × 2300.

Fig. 11. Primary sporocyte; metaphase showing completed spindle. C-centrosome. × 2300.

Fig. 12. Primary sporocyte, anaphase showing division of tetrads into dyads. D-dyads. C-centrosome. × 1800.

Fig. 13. Secondary sporocyte; metaphase showing arrangement of elongate dyads in the nuclear plate. C-centrosome. × 1800.

Fig. 14. Late anaphase of the division of the secondary sporocyte showing the four nuclei free in the cell, with connecting spindle fibres. × 2300.

Fig. 15. Early spores. The cell plates have formed; remnants of the spindle fibres can still be seen. × 1800.

Fig. 16. Young spore. Nucleoli have reappeared. × 1800.

Fig. 17. Primary archesporium; a few of the chromosomes during the early stage of division. They are distinctly double. × 2300.

Fig. 18. Somatic cell from a young fern plant, in division. × 2300.

Fig. 19. Primary sporocyte (*Adiantum*) showing formation of tetrads. C-ring form. A-cross form. × 2300.

Fig. 20. Primary sporocyte showing division of tetrads into the nuclear plate. C-ring forms. × 2300.

Fig. 21. Primary sporocyte showing division of the tetrads to form dyads. (D). × 2300.

Notes on the Influence of Light on certain dorsiventral Organs.

By Katharine Cleveland Burnett.

(Plate 297.)

The influence of light on morphology and anatomy of dorsiventral organs comprises a most important part of plant physiology. It is necessary therefore to explain that the work set forth in this paper is of a very limited character, owing to the short time available in a laboratory course, so that the subject should be limited to the study of the influence of light on the morphology and anatomy of dorsi-ventral organs of two plants studied during the months of March, April and May.

The influence of light on a plant may be negatively studied by watching its behavior when deprived of light. The results of this deprivation are morphological, anatomical and physiological, and are known as the phenomena of etiolation.

Some of these results are well known and prominent, many are exceptional and disputed.

As a general thing, we notice morphologically the lengthening of the internodes and the smallness of dorsi-ventral leaves; also, that the leaves make a very small angle with the stem.

Studied from an anatomical point of view, the vascular and thick-walled tissues are found to be much less developed in the internodes, and no differentiation of palisade and spongy tissue is found in the leaves; this is almost a physiological point, being connected with the non-formation of green chlorophyll pigment. A green plant deprived of light forms no green chlorophyll pigment and even loses that which it already has formed.

It has been stated by various authorities that a dorsi-ventral leaf owes its differentiation of palisade and spongy tissue entirely to the influence of light, and *that* for a distinct purpose. According to Vines,* "palisade layers occur always beneath the epidermis of those surfaces which are directly exposed to the sun's rays. If a plant be grown in the shade the palisade layers are imperfectly differentiated even if they can be detected at all. Development of palisade layers is clearly a peculiarity of leaves which are exposed to sunlight. Bright light promotes assimilation and oxida-

* Vines. A Students' Text-Book of Botany, 686–687.

tion and decomposition of chlorophyll. Palisade tissue affords protection from the latter effect. When there is diffuse daylight the chlorophyll corpuscles are arranged horizontally along the upper surface of the cells. In direct sunlight they are vertical. The elongated form of the palisade tissue facilitates this withdrawal. The spongy tissue is especially adapted to transpiration, so in submerged water plants we find no palisade nor spongy tissue. First, the light is not intense. Second, they do not transpire."

Furthermore, MacDougal, in his *Experimental Plant Physiology*,* says that if young leaves of beech be turned so that the morphological under surface becomes the upper, the palisade will be found on what was originally the under surface.

The following investigations were made for the purpose of verifying these statements, and, furthermore, to see if the tissues of the leaf could be changed after the anatomical differentiation had taken place, that is, after the palisade tissue had formed could the leaf then be turned and palisade tissue be formed on the side now exposed to light.

The plant experimented with was the *Salix alba*. Young twigs were obtained April 17th with buds ½ cm. long, slightly swollen but still covered with scales, the leaves, therefore, were not exposed directly to the influence of sunlight (a).

On cross-sectioning a bud the tissue of the leaves showed regularly arranged parenchymatic tissue with no differentiation of palisade or spongy (b).

The twigs were put in water, some in the dark and some exposed to light, to see whether the willow showed any exceptions to the ordinary facts of the etiolation. Ten days later, April 27th, the willow grown in darkness showed well marked etiolation. The terminal bud had grown 3½ cm., being now 4 cm. long, the the lateral buds only from 1–2 cm. The internodes varied in length from ¼ cm. to 1 cm. The leaves were small, from ½ to ¾ cm. in length; they made a small angle with the stem and had no green chlorophyll pigment.

On cross-sectioning, the anatomy had changed but little from that of the bud studied ten days earlier. There was a very slight

* Pp. 73–74.

lengthening, vertically, of the first layer of cells under the epidermis of the upper surface, but no further differentiation, merely a growth in size and number of cells.

The bud grown in light had developed in six days (April 23) as follows: (c) The entire bud had lengthened, being now 1 ¼ cm.; all but one scale had fallen off. The outer, lower leaf was ¾ cm. long and of a delicate green color, the leaves showed no sign of hyponasty, but were closely folded around the stem. The bud was then cross sectioned to see the anatomical changes, if such had occurred. The outer lower leaf showed a slight indication of palisade tissue by the lengthening of the first row of cells under the upper epidermis (d.) This surface had not been exposed to direct rays of light, the under surface directly exposed to light showed no sign of palisade tissue. These facts indicate that the formation of palisade tissue is the result of an inherent quality of the leaf, only assisted and not induced by light.

An inner, upper leaf of the bud, still enclosed by the outer leaves on the cross section, showed no differentiation of palisade and spongy tissue.

On April 27th, on examining the bud grown in light, we find a different morphology and far greater anatomical changes than in the etiolated bud grown the same length of time. The bud is 1 ½ cm. long, the outer lower leaf 1 cm. long, large leaf and short internodes as opposed to small leaves and long internodes of the etiolated bud examined. This outer leaf forms a small angle with its stem for ¾ of its length when its upper surface has grown very rapidly, so that the remaining ¼ of the blade makes an angle of 90° with the stem, so that this part of the surface receives direct rays from the sun. This leaf is bright green. On examination by cross sectioning we see decided development; a well formed layer of palisade tissue under upper epidermis, spongy tissues on under surface, many stomata and large air spaces.

On April 30th, after two weeks' growth, the leaves are opening still further. The outer lower leaf, corresponding to the leaf studied, April 27th, makes an angle of 45°, half its length from the base and the rest of the way an angle of 90°. The second leaf just above is at an angle of 45° throughout its entire length. The other leaves are still folded about the stem. The anatomical

differences are slight. The lower leaf shows no change. The one above it (f) just showing hyponasty is forming palisade and spongy tissues, and corresponds in its anatomy to the outer leaf studied April 27th. The next leaf, still folded on the bud, (g) shows a layer of palisade tissue and a slight formation of spongy tissue.

To sum up: in all these cases examined, the leaves, whose upper surfaces were appressed against the stem and so had in no case been directly exposed to light, showed beginning of formation of palisade tissue. The under surface being at this same time exposed to direct rays of sunlight, formed no palisade tissue whatever. Therefore, the results of these observations show that the general statements made regarding change in form of tissues in young leaf do not always hold true, as the palisade tissue is already formed on morphological upper surface before it has been exposed to direct sunlight and before the leaf can be turned.

There remains now the second consideration, namely, to see if, after the leaf has been turned, the tissues can be changed.

Two methods for experimenting were adopted. In the first the bud was tied April 30th, so that the leaf could not turn its upper surface to the light (h). On May 6th, six days later, on cross sectioning this leaf, the upper surface showed two well formed layers of palisade tissue (i). On the morphological under surface exposed to light, two rows of palisade tissue were formed, but not directly under the epidermis, the layer immediately under the epidermis being ordinarily formed cells with intercellular spaces. Another leaf, grown normally, was examined the same day, May 6th, and was found to be typical, that is with two rows of palisade tissue on upper surface and very loose spongy tissue on under surface.

The second method adopted was to turn the leaf over on its petiole so that the morphological under surface becomes the upper, and fasten the leaf with a split match. Owing to the leaf having been disturbed at various times, the result was not very successful. On examination the morphological upper surface turned away from the light still showed two rows of palisade tissue, but the cells have intercellular spaces as though taking on the nature of spongy tissue. The under surface now exposed to light shows tissue with less indication of intercellular spaces, but the cells are

not lengthening in palisade form. This latter was not a fair test, as the plant had not been properly cared for. The results obtained in the tied leaf were more satisfactory, indicating that palisade tissue already formed could not be changed, but that the parenchymatic tissue of the under surface, if exposed to light for a long time, would take on the palisade characteristics for the protection of the leaf from too intense light.

The *Lunularia*, being a plant whose dorsi-ventrality is marked by its structural peculiarities, was next investigated.

It may be well to speak briefly of its normal structure.* Campbell describes it thus: "The thallus is made up largely of parenchyma. The dorsal part occupied by a single layer of definite air chambers opening at the surface by a single pore, seen from the surface they form a network. The thallus is fastened by unicellular rhizoids from the dorsal surface. One of the methods of asexual reproduction is by the so-called gemmae. These gemmae are produced in special receptacles upon the *dorsal* side of the thallus, and are crescent-shaped in *Lunularia*. These cups are specially developed air chambers, which open. The gemmae arise from the bottom as papillate hairs; one papilla projects, and a wall is formed, separating this projection from the surface of the cup; this outer cell is again divided by horizontal walls until four are formed. Each of these four primary cells is divided by a vertical wall, the young thallus being but one layer in thickness (k, l, m, n, o.), but later walls appear in the central cells parallel to the surface, so it is lenticular. As it grows older, two growing points are established and lie in a depression so the older gemma is fiddle-shaped. The gemma is vertical, therefore has no distinction of dorsum and ventrum. The further development depends upon light. Whichever side touches the ground develops rhizoids; as soon as it becomes fastened to the ground the dorsi-ventrality is established."† Sachs says: "Certain cells on both convex sides are destined, according to circumstances, to grow out into root hairs; if both surfaces are equally illuminated, those grow which are able to follow influence of gravity. Zimmerman says influence of light is stronger, as if lower surface is illuminated

* Mosses and Ferns, 45–46.

† Physiology of Plants, 526.

the roots of shaded side develop." Pfeffer suggested it was partly due to action of gravity and effect of contact with substratum, but chiefly to influence of light.

The *Lunularia* (k, l, m, n, o.) in the laboratory had well developed gemmae cups ¼ cm. in the long diameter, in which were gemmae in all stages of development, from four-celled up to detached gemmae of plates of several layers. These last were the characteristic fiddle shape and were .45 to .5 mm. in size. Several dozens of these tiny gemmae were planted in moist earth March 2d. Three days later (March 5th), tiny rhizoids .1 mm. long had grown on surface touching the earth, the gemmae had grown to .97 by 0.5 mm. in length and breadth.

Several were then *turned* so that the upper side now became the side touching the earth, and allowed to grow four days, from March 5th to 9th. On examination long rhizoids 1 to 1.05 mm. in length had grown on what had been the upper surface, so we had the curious phenomenon of a gemmae with rhizoids on both surfaces. (p.a. q.b.)

We next tried to find at what stage of development the anatomical characteristics become permanent, so that no change can be induced by change in position.

Gemmae grown six days and having formed long rhizoids from 1 to 2 mm., on being turned, did not develop rhizoids on the dorsal surface.

Full grown thallus, with tips turned, produced no result, so that the conclusion here is that, though dorsi-ventrality can be induced by light and other accessory assistants, yet, after a certain development of the thallus, and that early in its history, the dorsi-ventrality becomes permanent and turning produces no change.

Explanation of Plate 297.

a. Young twig of willow, buds still covered with scales, × ¾.
b. Cross section of a leaf from one of the buds, × 90.
c. Bud with leaves still folded, × 1½.
d. Section of outside leaf showing first indication of palisade tissue, circa × 190.
e. Bud unfolding showing leaves 1, 2, 3, × 1½.
f. Cross section of leaf 2, showing palisade tissue, circa × 190.
g. Cross section of leaf 3, showing palisade tissue, circa × 190.
h. Leaf tied so under surface is exposed to light, × 1½.
i. Cross section showing palisade tissue on both under and upper surfaces, circa × 190.

k. Thallus of *Lunularia* with gemmae cups, × 2¼.
l, m, n, o. Stages in development of gemmae, circa × 50.
p. a. q. b. Gemmae with rhizoids aa. bb. grown on both ends, circa × 30.

A new fossil Grass from Staten Island.

By Arthur Hollick.

(Plate 298.)

Phragmites Aquehongensis n. sp.

Culms round, narrowly striate longitudinally, articulate, occasionally dotted with one or more circular scars immediately above the articulations; internodes short; rhizomes tuberous, branching, consisting of irregularly rounded, articulated parts, which are longer than broad, with knots or scars either at the joints or between them; leaves wanting.

Locality: Clifton, Staten Island, N. Y.

The first discovery of specimens representing this species was made in 1894, but these merely consisted of a few fragments of jointed stems and I referred them at the time to *Equisetum*.*

Subsequently better specimens were obtained, consisting not only of jointed stems, but also of tuberous rhizomes, and their affinity with the monocotyledons was then satisfactorily established.†

The generic name *Phragmites* has been finally adopted largely for the reason that similar fossil fragmentary remains have been described and figured under that genus, and not necessarily because our specimens are supposed to belong in it without question, although they certainly represent some grass. The specific name is coined from "Aquehonga," the Indian name for Staten Island.

The specimens figured are fairly representative of the material collected. They consist of fragments of culms and rhizomes, preserved in a conglomerate of yellow gravel, cemented with limonite.

This conglomerate is not in place where found, but forms part of the drift material, beneath the bowlder till, on the extreme southern edge of the terminal moraine. It was uncovered by reason of an excavation having been made there for building sand

* Proc. Nat. Sci. Assn. Staten Isld. 4: 37.
† Ibid. 6: 12.

and is associated with "kaolin" and white plastic clay, presumably of Cretaceous age; yellow gravel and sand, representing probably a recent Tertiary horizon and water-worn fragments of serpentine rock. These materials form a sort of hummock, beneath and distinct from the typical red bowlder till on top and afford every evidence of having been carried forward by the advancing glacier of the Ice Age, which, upon melting, deposited on top the debris which we call the bowlder till.*

The conglomerate, with its included fragments of vegetation, is, therefore, certainly pre-glacial in age. The direction of glacial movement on Staten Island was from the northwest, and as a line from the locality in question towards this point of the compass would cross the serpentine and limonite area of the Island we would naturally infer that it was from there that the conglomerate was derived. Throughout this area there are numerous deposits of limonite, associated with yellow gravel under favorable conditions, occupying basin-like depressions in the serpentine and evidently representing old swamps, around or in which a semi-aquatic vegetation flourished, prior to the advent of the Ice Age. Furthermore, as no such combination of yellow gravel, limonite and serpentine is known to occur elsewhere on the line of glacial movement, towards the locality where the conglomerate was found, we are justified in inferring that our specimens are native to Staten Island.

The problem of the exact geologic age of the yellow gravel conglomerate and, therefore, of the vegetation contained in it, has not been completely solved. Upon stratigraphic grounds Professor R. D. Salisbury decided it to belong to his Beacon Hill formation, which he classes as Miocene Tertiary in age.† It is, therefore, of interest to ascertain how the evidence afforded by fossil plants compares with this conclusion.

Grasses, as fossils are comparatively rare, and are not definitely known prior to the Tertiary period, although monocotyledons under the generic names of *Poacites*, *Bambusium*, *Culmites*, *Arundo* and

*For the geological features of the locality see description in Proc. Nat. Sci. Anss. Staten Isld. 2: 8; 3: 8; 3: 45–47, and Trans. N. Y. Acad. Sci. 11: 104; 14: 15, *fig. 4*.

† Ann. Rept. State Geol., N. J., 1894, 100; 1895, 3.

Phragmites, have been described from Cretaceous and even older horizons, but fossils which can be unquestionably referred to the grasses can hardly be said to date back beyond the Eocene Tertiary.*

The figures with which ours may be most closely compared are of species from either Eocene or Miocene strata in the Old World or Greenland, included under the genera *Phragmites*† and *Arundo*.‡ I do not know of any having been heretofore described from the eastern United States, although broad grass-like leaves, which I am inclined to refer to *Phragmites*, occur in the yellow gravel sandstone at Bridgeton, N. J., as previously noted by me.§

The flora of the Bridgeton sandstone is almost certainly Miocene or early Pliocene in age, and we may safely refer our species to about the same horizon. It is greatly to be desired that leaves should be found in connection with the Staten Island specimens and that culms and rhizomes be found at Bridgeton. Should such discoveries be made, a more exact comparison between the two floras would be possible.

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*For a general discussion of this subject see "Fossil Grasses," J. Starkie Gardner, Proc. Geologists Assn. **9**: No. 6, in which copious references may be found.

†*P. Oeningensis* Al. Braun.

Heer. Fl. Tert. Helvet. **1**: 64. *pl. 22, figs. 5a–e; 24; 27, fig. 2b; 29, fig. 8e.*

Ludwig, Palæontog. **8**: 80. *pl. 16, figs. 1–1c; 18, figs. 2–2i; 24, fig. 7.*

Ettingsh. Fl. Bilin, 97 [21] *pl. 4. figs. 6–10.*

‡*A.* (*Donax*) *Goepperti* (Münst.) Heer, Fl. Tert. Helvet. **1**: 62. *pl. 22. figs. 3a, b; 23.*

Ettingsh. Fl. Bilin, 95 [19] *pl 4. figs. 1–4.*

Ludwig, Palæontog. **8**: 80. *pl. 17.*

A. anomala (Brong.) Heer, Fl. Tert. Helvet. **1**: 63. *pl. 22, fig. 4.*

§Bull. Torrey Bot. Club, **19**: 330–333.

New Species of Fungi from various Localities.

By J. B. Ellis and B. M. Everhart.

HYMENOMYCETES.

Polystictus obesus E. & E.

On the ground, in contact with, and partly attached to decaying pine limbs partly buried in the soil, Newfield, N. J., and Fairmount Park, Philadelphia, Pa.

Stipitate. Stipe central, spongy, velutinous, dark cinnamon, 4–6 cm. high, ½–1½ cm. thick above, enlarged below to 1–3 cm.; pileus convex then depressed in the center, obconical at first with the margin obtuse, then spreading out with margin acute, color lighter than that of the stipe, yellowish-cinnamon, surface uneven, velutinous, sub-colliculose, not zonate, 4–6 cm. across; pores irregular, short (1 mm.), at first round with margins thick, finally irregular and subsinuous, ½–1 mm. across, margins acute; spores elliptical, ferruginous, 7–8 × 4–5 μ.

This might, perhaps, be considered a thick-fleshed form of *Polystictus perennis* (L.). The tomentose-velutinous covering of the pileus and stipe is the same as that of *Mucronoporus tomentosus* (Fr.), but the hymenium is unarmed.

Corticium portentosum crystallophorum E. & E.

On bark of dead trees or logs, St. Martinville, La., December, 1895. (Langlois, no. 2438.)

Closely adnate, roughened by the inequalities of the bark, cream-color, about ½ mm. thick, in parts, stratose, tough, coriaceous, margin determinate, texture of densely and closely interwoven fibrils, enclosing abundant coarse amorphous crystals, confluent for 10 cm. or more, and 4–6 cm. wide; margin here and there obscurely and briefly subfimbriate. Has the general appearance of *C. leve* Pers.

Differs from the type in the abundant amorphous crystals.

Cyathus rufipes E. & E.

Underside of old sods, in a plowed field, Rooks Co., Kansas, July, 1893 (E. Bartholomew).

Peridium slender-obconical, about 1 cm. high and 4 mm. wide, thin, dark lead color and smooth inside (not striate above, covered outside with a coarse tow-colored strigose-tomentose coat, and with a tuft of reddish-brown tomentum at the base, margin conni-

vent, uneven; sporangiola discoid, 1¼ mm. in diameter, becoming dark, concave and wrinkled when dry, the surface overrun with slender (3 μ thick) brown interwoven threads. Spores globose or elliptical, 20–27 × 15–20μ.

Growing (sec. Mr. B.) "head downward." Distinguished by its slender growth, large spores, and the tuft of reddish-brown tomentum at the base.

MELIOLA ACERVATA E & E.

On leaves of *Physalis Peruviana*, Kaui (S. I.). 1895. (A. A. Heller, no. 2773.)

Epiphyllous. Perithecia globose, 150–200 in diameter, of coarse cellular structure and like the mycelium unarmed, collected in little heaps or dense clusters 1 mm. in diameter or less, and fringed with abundant brown branching mycelium of the usual type; capitate hyphopodia alternate, obovate, 12–14 × 8–10 μ; mucronate hyphopodia less abundant, smaller, ovate, opposite, with a slender straight beak 6–8 μ long; asci oval, short-stipitate, 40 × 20 μ, 2–4-spored; sporidia oblong-cylindrical, obtuse, 4-septate, scarcely constricted, 30–35 × 12 μ.

ASTERINA SPHAERELLOIDES E. & E.

On leaves of *Clematis persicaefolia*, Sandwich Islands, 1895. (Heller, no. 2394.)

Mycelium reticulated, brown, forming small black suborbicular spots (1 mm. diameter), often subconfluent; perithecia seated on the mycelium, black, ovate-globose, papillate, 80–90 μ in diameter; asci oblong, sessile, aparaphysate, 30–35 × 10–12 μ; sporidia irregularly biseriate, pyriform, uniseptate, brown, not constricted, 10–12 × 3–3½ μ.

There was also an immature *Meliola* on the same leaves.

ROSELLINIA CONFERTISSIMA E. & E.

On rotten wood, Ohio. (Morgan, no. 1173.)

Perithecia superficial, densely gregarious, globose, 350–500 μ in diameter, thin-walled and brittle, farinose-pubescent, becoming nearly glabrous; ostiolum prominent, mammiform; sporidia elliptical, 8–10 × 4 μ, continuous, brown.

ROSELLINIA MACRA E. &. E.

On leaves of some monocotyledonous plant, Florida. (Morgan no. 1134.)

Perithecia gregarious, superficial, convex-flattened, ¼–⅓ mm. in diameter, not polished, ostiolum papilliform, minute; asci (in the specimens examined) not seen; sporidia oblong-elliptical, brown, subacute, 20–30 × 10–12 μ, some of them with a paler streak across the middle but not truly septate.

Differs from *R. sublimata* Dur. & Mont. in its much smaller thinner perithecia, and from *R. hemispherica* Sacc. & Paol. and *R. amblistoma* Berl. & Sacc. in its much smaller spores. Perithecia almost as in *Microthyrium*.

Ceratostoma biparasiticum E. & E.

On the stipe of *Isaria farinosa* (Dicks.) Fr. Ohio (Lloyd).

Perithecia ovate, 80–100 μ in diameter, enveloped in a white mucedinous subiculum of loosely interwoven hyaline threads about 3 μ thick, enveloping the lower part of the *Isaria* stipe, and bearing subglobose hyaline conidia 2 × 1½ μ; asci clavate-lanceolate, p. sp. 20 × 6 μ, short-stipitate (paraphysate?); sporidia fasciculate, 8 in an ascus, oblong-cylindrical, olivaceous, 6–2 × 1½ μ. The beak of the perithecium is of a grayish-brown, of fibrous structure and about 1 mm. long × 35–40 μ thick.

Teichospora Nepetae E. & E.

On dead stems of *Nepeta Cataria*, Granton, Ontario, Canada, August, 1895. (J. Dearness, no. 2351.)

Perithecia scattered, superficial, depressed, 220–250 μ in diameter, collapsing; ostiolum papilliform, distinct; asci clavate-cylindrical, nearly sessile, gradually narrowed downward, 70–80 × 12–15 μ; paraphyses linear, stout, 2–2½ μ thick; sporidia biseriate, clavate-oblong, slightly curved, 5–7-(mostly 6-)septate, sometimes strongly constricted in the middle, 20–22 × 6–7 μ (exceptionally reaching 25 × 10 μ), yellow-brown, one or two cells divided by a longitudinal septum.

Closely allied to *Teichospora vitalbae* De Not. but that (sec. Berlese) has perithecia 300–350 μ in diameter, and asci cylindrical, 120–130 × 11–13 μ. *T. clavispora* E. & E. has rather larger (250–300 μ) perithecia, not collapsing, and longer 8–10-septate sporidia.

Cucurbitaria Astragali E. & E.

On dead stems of *Astragalus* sp., Rooks county, Kansas. August, 1895. (E. Bartholomew, no. 1894.)

Perithecia gregarious or crowded, erumpent-superficial, globose-hemispherical, minutely roughened, 500–650 μ in diameter, finally collapsing above; ostiolum black, conic-papilliform; asci clavate-cylindrical, stipitate, paraphysate, 85–100 × 9–10 μ; sporidia overlapping, uniseriate, oblong-fusoid, sub-acute below, obtuse above, 3-septate, slightly constricted at the middle septum, hyaline at first, then pale yellow, generally with one cell (sometimes two cells) divided by a longitudinal septum, 15–20 × 6–8 μ; stylospores in similar perithecia, oblong-elliptical, uniseptate, scarcely constricted, nearly hyaline, 6–8 × 3–3½ μ.

MELANOMMA CUPULATA E. & E.

On decorticated *Salix*, Mt. Paddo, Wash., alt. 7000 ft. (Suksdorf, no. 484.)

Perithecia scattered or gregarious, superficial, brownish-black, membranous, clothed with short (20–40 × 2 μ) continuous spreading subundulate brown hairs, finally collapsing to cup-shaped, with a papilliform ostiolum. Where the perithecia stand close together the surface of the wood is often covered with a felt-like olive-black subiculum, formed of branching brown closely septate hyphae; asci clavate-cylindrical, 45–60 × 8 μ, with indistinct paraphyses; sporidia biseriate, oblong-fusoid, pale brown, 3-septate, not constricted, 10–12 × 3½–4 μ.

Closely allied to *C. pilosella* Karst., but perithecia collapsing and asci and sporidia somewhat smaller.

LOPHIOTREMA FRAXINI E. & E.

On decorticated *Fraxinus viridis*, Rooks Co., Kansas, March 30, 1896. (Bartholomew, no. 2101.)

Perithecia scattered or gregarious, semi-emergent, depressed-spherical, brown, 400–500 μ in diameter; ostiolum variable, papilliform, compressed-conical, or extending ⅓ across the perithecium; asci clavate-cylindrical, 85–90 × 10 μ; sporidia biseriate, fusoid, acuminate, hyaline, 5- or more nucleate, becoming 3- or more septate, scarcely constricted, 35–42 × 4½–6 μ, mostly about 5 μ thick.

L. Fontanesiae Pass. and *L. Coryli* H. Fabre have sporidia about the same as this, but differ otherwise.

LOPHIOTREMA OENOTHERAE E. & E.

On dead stems of *Oenothera biennis*, Newfield, N. J., Aug., 1895.

Perithecia subgregarious or scattered, erumpent-superficial, minute (about ¼ mm.), ovate-globose, with a narrow, but promi-

nent, compressed ostiolum; asci clavate, 45–55 × 7 μ, paraphysate; sporidia biseriate or oblique, oblong-fusoid, 4-nucleate, becoming faintly 3-septate and slightly constricted in the middle, hyaline subobtuse, straight or slightly curved, 12–13 × 3–3½ μ.

LOPHIDIUM TRIFIDUM E. & E.

On decorticated *Salix*, Mt. Paddo, Wash., alt. 7000 ft. (Suksdorf, no. 483.)

Perithecia gregarious, ovate-conic, about 1 mm. in diameter the broad base lightly sunk in the wood, mostly with an acutely elliptical depression at the top, in the center of which is the narrow, inconspicuous ostiolum. When old and empty, the perithecia open above with three broad laciniae; asci cylindrical, 130–150 × 12 μ, including the short stipe; sporidia uniseriate, oblong-elliptical, 5-septate, with one or more cells divided by a longitudinal septum, slightly constricted in the middle, 20–23 × 12 μ.

Comes near *C. Populi* H. Fabre.

LOPHIDIUM RUDE E. & E.

On weather-beaten cottonwood shingle, Smith Co., Kansas, April, 1896. (Bartholomew, no. 2102.)

Perithecia scattered or gregarious, semi-emergent, subglobose, brown, not polished, ½–¾ mm. in diameter; ostiolum short-cylindrical, only slightly compressed; asci cylindrical, 8-spored, paraphysate, p. sp. 75–80 × 12–14 μ; sporidia uniseriate, oblong-elliptical or oblong-cylindrical, brown, 4–8-septate, not constricted, obtuse, with a longitudinal septum, more or less distinct, running through two or more of the cells, 22–35 × 8–12 μ.

Many of the sporidia show no longitudinal septum.

LAESTADIA RUBICOLA E. & E.

On dead stems of *Rubus strigosus*, Granton, Ontario, Canada, Aug., 1895. (J. Dearness, no. 2353.)

Perithecia thickly scattered, subcuticular, depressed-hemispherical, collapsing, and by the falling away of the papilliform ostiolum, broadly perforated above; asci clavate-cylindrical, stipitate, 60 × 7–8 μ, (p. sp.), narrowed and acute above and below; paraphyses obscure, shorter than the asci; sporidia biseriate, oblong-elliptical, hyaline, 2-nucleate, ends obtusely rounded, 12–14 × 5–6 μ.

LAESTADIA SCROPHULARIA E. & E.

On dead stems of *Scrophularia*, London, Canada, August, 1895. (J. Dearness, no. 2342.)

Perithecia scattered, subcuticular, 100–130 μ in diameter, visible through the epidermis which is slightly raised; asci clavate-cylindrical, 35–40 (p. sp. 25–30) $\times$ 6–7 μ; sporidia biseriate, oblong, obtuse, nucleate, continuous, hyaline, 9–12 $\times$ 3 = 3–3½ μ.

In *L. Epilobii* Wallr., the perithecia collapse and the sporidia are larger (13–17 $\times$ 3–4 μ).

DIDYMOSPHAERIA MAJOR E. & E.

On decorticated wood of *Rhus glabra*, Rooks Co., Kansas, September, 1895. (Bartholomew, no. 1934.)

Gregarious, covered by the blackened surface of the wood which is raised into pustules pierced by the papilliform ostiola; perithecia buried in the unchanged substance of the wood, about 300 μ in diameter; asci cylindrical, 90–105 $\times$ 10–12 μ, short-stipitate, paraphysate, 8-spored; sporidia uniseriate, mostly oblique, oblong-elliptical, uniseptate, slightly or not at all constricted, pale brown, obtuse, 12–18 $\times$ 7–8 μ.

Differs from *D. rhoina* E. & E. on the same host, in its larger asci and sporidia.

DIDYMOSPHAERIA RHOINA E & E.

On weather-beaten, decorticated limbs of *Rhus glabra*, Rooks Co., Kansas, September, 1895. (Bartholomew, no. 1935.)

Perithecia gregarious, covered, ovate-globose, 350–450 μ in diameter, with a conic-papilliform erumpent ostiolum; asci cylindrical, short-stipitate, paraphysate, 60–70 $\times$ 6 μ; sporidia uniseriate, elliptical, pale brown, scarcely constricted, 7–8 $\times$ 4–5 μ.

Differs from *D. conoidea* Nessl. in its rather smaller elliptical sporidia, and its rather smaller permanently covered perithecia.

PHYSALOSPORA SUBERUMPENS E. & E.

On bark of dead *Eucalyptus globulus*, California (McClatchie).

Perithecia gregarious, at first covered by the pustuliform-elevated epidermis, then semi-erumpent, white inside, ¼–⅓ mm. in diameter, the erumpent apex conic-hemispherical, crowned with the strongly papilliform or conic-papilliform ostiolum; asci broad, clavate-cylindrical, 80–100 $\times$ 18–20 μ; sporidia irregularly crowded, elliptical or ovate-elliptical, hyaline, 18–21 $\times$ 9–11 μ.

Accompanied by a *Sphaeropsis* in similar but rather larger perithecia, with oblong-elliptical brown sporules, 18–22 $\times$ 10–12 μ.

AMPHISPHAERIA SEPARANS E. & E.

On old cottonwood shingle, Smith Co., Kansas, April, 1896. (Bartholomew, no. 2104.)

Perithecia subgregarious, ovate-conical, grayish-brown, about ½ mm. in diameter, 1 mm. high, base slightly sunk in the wood; ostiolum stout, short-cylindrical, black, rough, obtuse; asci cylindrical, 110 × 12 μ, paraphysate, 8-spored; sporidia elliptical, narrowed at the ends, but obtuse, brown, uniseptate, deeply constricted and easily separating at the septum, 20–23 × 9–11 μ.

LEPTOSPHAERIA RHOINA E. & E.

On decorticated wood of *Rhus glabra*, Rooks Co., Kansas, Sept., 1895. (Bartholomew, no. 1933.)

Perithecia gregarious, buried in the surface of the weather-beaten wood which is raised into small pustules over them, globose or short-elliptical, 200–250 μ in diameter; ostiolum papilliform, erumpent; asci clavate-cylindrical, 60–70 × 8–10 μ, short-stipitate, paraphysate; sporidia biseriate, fusoid, slightly curved, 3–5- (mostly 5-) septate, constricted at the septa, yellow-brown, 16–22 (mostly 20) × 5–6½ μ.

Closely allied to *L. Baggei* (Awd. and Niessl.), which has rather larger perithecia, broader asci (70–90 × 16–20 μ) and longer sporidia.

PLEOSPORA CRANDALLII E. & E.

On dead stems of *Androsace Chamaejasme*, above the timber line, Cameron Pass, Colo., alt. 12000 feet, July 6, 1894. (Prof. C. S. Crandall, no. 237.)

Perithecia scattered, semi-erumpent, obtusely conical, 200 μ in diameter, with a papilliform ostiolum; asci oblong, subsessile, with very short nodular stipe, 75–80 × 20–22 μ, with indistinct paraphyses; sporidia crowded, biseriate, oblong or slightly obovate-oblong, 5-septate, scarcely constricted, 2 or more of the cells divided by a longitudinal septum, 20–22 × 10–12 μ, ends obtusely rounded.

Differs from *P. media* Niessl. in its smaller conical perithecia not collapsing.

DILOPHIA MAGNOLIAE E. & E.

On dead limbs of *Magnolia Fraseri*, Nuttallberg, West Va., May 12, 1896. (L. W. Nuttall, no. 849.)

Perithecia in circinate clusters of 3–6, seated on the inner bark, ovate-globose, membranous, ½–¾ mm. in diameter, with the short cylindrical, subsulcate-cleft or smooth ostiola slightly erumpent in a rather loose fascicle; asci clavate-cylindrical, short-stipitate, 90–110 × 8–10 μ; paraphyses inconspicuous or none; sporidia biseriate, oblong-fusoid, hyaline, becoming 1-

(3-?) septate, 20–23 × 5–6 μ, slightly curved, with a slender hyaline bristle-like appendage 15–30 μ long at each end; stylospores in ovate-conical scattered erumpent perithecia, with sporules shaped like the ascospores, only smaller (14–16 × 4–5 μ) and lacking the bristle-like appendage. When the outer bark is stripped off, the perithecia either adhere to it or remain attached to the surface of the inner bark.

DIAPORTHE AORISTA E. & E.

On dead stems of *Solidago* sp., Newfield, N. J., July, 1896. (N. A. F. 3432.)

Perithecia scattered or gregarious, often 2–3 subconfluent, sometimes subseriately arranged, slightly sunk in the unaltered substance of the stem without any black circumscribing line, slightly raising the epidermis which is not discolored, or at most only slightly blackened where the perithecia stand close together, globose, small (300–350 μ); ostiola exserted, stout, roughish, conic-cylindrical, short; asci oblong-cylindrical, p. sp. 35–45 × 8 μ; sporidia biseriate, oblong, uniseptate, slightly constricted, 2–4-nucleate, obtuse, hyaline, 11–13 × 4–4½ μ.

Differs from *D. orthoceras* (Fr.) in its rather smaller, only slightly buried perithecia and broader sporidia. *D. exercitalis* Pk. also has narrower sporidia and distinctly seriate perithecia.

DIAPORTHE LIGUSTRINA E. & E.

On dead *Andromeda ligustrina*, Newfield, N. J., April, 1896.

Perithecia thickly scattered, buried in the unaltered substance of the bark, about ⅓ mm. in diameter; ostiola subconical, tuberculiform or subglobose, often seriate in longitudinal cracks in the bark, distinctly erumpent so as to appear like superficial perithecia; asci clavate-oblong, 50–60 × 8–10 μ; sporidia subbiseriate, fusoid at first but when mature obtusely rounded at the ends and constricted in the middle, about 10 × 4 μ or 9–11 × 3½–4½ μ.

VALSA SOCIALIS E & E.

On dead limbs of *Salix cordata*, Rooks Co., Kansas. (E. Bartholomew, no. 2099.)

Stromata circinate or gregarious, cortical, not circumscribed, small (1–2 mm.), raising the epidermis into small pustules often arranged in a circle around a central one; perithecia buried in the unaltered substance of the bark, ½ mm. in diameter, abruptly contracted into slender necks with the minute black ostiola at first covered by a pale white disk, but finally erumpent though not exserted; asci subcylindrical, about 60 × 6 μ (p. sp.); sporidia sub-

biseriate, allantoid, obtuse, moderately curved, hyaline, 12–16 × ½–3 μ; each of the small stromata contains 1–6 perithecia.

Valsa Celtidis E. & E.

On dead limbs of *Celtis occidentalis*, Rooks county, Kansas, March, 1896. (E. Bartholomew, no. 2082.)

Stroma cortical; perithecia circinate, immersed in the unaltered substance of the inner bark, ovate, with coarsely cellular membranous wall, about ½ mm. in diameter, with necks convergent and obscure ostiola united in an erumpent black disk; asci oblong-lanceolate, 40–50 × 13–15 μ; sporidia biseriate, oblong or oblong-elliptical, very slightly curved, 14–18 × 5–6 μ, ends rounded and obtuse; the perithecia occur in subconfluent groups of 12–20 and are often laterally collapsed; the young stromata are multicellular, orbicular and depressed, the cells filled with allantoid, hyaline spermatia, 5–6 × 1¼ μ, exuding in nearly black thick wax-like cirrhi.

Valsa Amorphae E. & E.

On dead limbs of *Amorpha fruticosa*, Rooks Co., Kansas, Feb., 1896. (E. Bartholomew, no. 2048.)

Perithecia circinate, 6–10 or more together, buried in the unchanged substance of the inner bark, ovate-globose, 300–350 μ in diameter, with coarsely cellular walls, often collapsing below when the bark is loosened; necks stout, cylindrical, convergent, their obtusely conical smooth black ostiola piercing the epidermis, and rising slightly above it, sometimes at first united in a black disk, which is soon obliterated; asci clavate-cylindrical, 75–80 × 10–12 μ, obscurely parayhysate, 8-spored, stipitate; sporidia subbiseriate, allantoid (often elliptical at first), hyaline, 10–18 × 3½–4½.

Possibly this might be considered a dwarf form of *Valsa dissepta* Fr., but all the specimens of that species in the different exsiccati have the perithecia and sporidia larger. This must not be confounded with *Eutypella Amorphae* E. & E. which is very distinct.

Eutypella Fici E. & E.

On dead limbs of *Ficus*, St. Martinville, La., March, 1896. (Langlois, no. 3443.)

Perithecia in subcircinate clusters of 4–6, depressed-globose, ¼–⅓ mm. in diameter, buried in the unaltered substance of the inner bark which is uniformly blackened on the surface, not penetrating to the wood or surrounded by any circumscribing line; ostiola short-cylindrical, 4-sulcate at the subacute tips, rising to-

gether in a close fascicle which pierces the epidermis, but rises only slightly above it; asci (p. sp.) clavate, 15–20 × 3½–4 μ; sporidia subbiseriate, yellowish, allantoid, curved, 3–3½ × 1 μ.

This might, perhaps, be considered a variety of *E. capillata* E. & E., but the habit is different and the perithecia smaller.

Calosphaeria acerina E. & E.

On dead limbs of maple, London, Canada, Sept., 1895. (Dearness, no. 2361.)

Perithecia subcuticular, circinate, 4–12, depressed-globose, thinly clothed with a gray villosity, black and shining inside, the inner substance of the wall white when cut through, inner cavity about 200 μ in diameter. Ostiola convergent and united in a minute disk which raises and finally perforates the epidermis, but projects but slightly above; asci clavate, p. sp. 35–40 × 6 μ; paraphyses 2–3 times as long as the asci; sporidia biseriate, allantoid, a little narrower at one end, only slightly curved, hyaline, 8–12 × 2–2½ μ. The ostiola are scarcely exserted.

Diatrype linearis E. & E.

On *Eucalyptus globulus*, California. (McClatchie.)

Stroma narrow, 2–6 mm. long, 1 mm. wide, sunk in the weather-beaten surface of the wood, erumpent but only slightly projecting, nearly flat above and bordered on each side by the raised fibers of the wood, acute at the ends and bearing considerable resemblance to *Glonium lineare*; perithecia 6–15, sunk in the stroma, globose, with rather thick coriaceous walls, 400–500 μ in diameter, dull white inside, roughened above by the slightly projecting papilliform or subconical ostiola; asci (p. sp.) about 60 × 7 μ or, including the filiform stipe, 120 μ long, paraphysate, 8-spored, sporidia subbiseriate above, allantoid, brownish, slightly curved, 7–10 × 2–2½ μ, mostly about 8 × 2½ μ.

Differing from *D. hochelagae* E. & E. in its narrower sunken stroma.

Melogramma horridum E. & E.

On dead beech, London, Canada. (Dearness, no. 2369.)

Stromata elongated, ½ cm. high, 2–3 mm. broad, densely caespitose-crowded and subconfluent, the surface colliculose, and roughened by the quadrisulcate stout spine-like ostiola like those of *Eutypa spinosa*, to which this bears outwardly a striking resemblance; perithecia ovate-globose, ⅓–½ mm. in diameter, with rather thin coriaceous walls, black and shining inside, sunk in the surface of the wood-colored stroma; asci cylindrical, 100–

110 × 10 μ (p. sp. 80–85 × 10 μ); sporidia uniseriate, elliptical, hyaline, 3-septate, each cell with 2 nuclei, hardly constricted, 14–16 × 7–8 μ, possibly becoming muriform.

NUMMULARIA ALBOSTICTA Ell. & Morgan.

On decaying hickory wood, Preston, Ohio. (Morgan, no. 1178.)

Stroma effused, thin, 1 mm. thick or a little over, 3–4 × 1 cm., mostly with a thin erect margin, slaty black, smooth, but dotted with the minute dirty-white punctiform ostiola; perithecia oblong, 1 × ¼–⅓ mm., crowded, asci cylindrical, 130 × 8–9 μ, stipitate, paraphysate; sporidia uniseriate, oblong-elliptical, subacute, pale at first, finally dark brown, 14–16 × 7–8 μ.

HOMOSTEGIA DIPLOCARPA E. & E.

On *Distichlis maritima*, Rooks Co., Kansas, Sept., 1895. (Bartholomew, no. 1923.)

Stroma subcuticular, black, convex, subelliptical, 1–2 mm. in diameter; ascigerous cells minute, subseriate, producing two kinds of stylospores: minute suballantoid hyaline 5–7 × 1½ μ; and cylindrical nucleate spores, becoming 3-septate, 14–23 × 4–4½ μ, hyaline, becoming subolivaceous.

CURREYA SANDICENSIS E. & E.

On living leaves of *Alphitonia ponderosa*, Sandwich Islands (Kaui), 1895. (A. A. Heller, no. 2758.)

Stromata hypophyllous, globose, 1–1¾ mm. in diameter, erumpent, grayish-black; ascigerous cells minute, globose, peripherical or subpolystichous, buried in the stroma which is dotted with the minute black punctiform erumpent ostiola; asci oblong-obovate, abruptly contracted below into a short stipe, 8-spored; sporidia irregularly crowded, cylindric-oblong, 3–5-septate, with one or two cells divided by a longitudinal septum, yellowish, 19–22 × 6–8 μ, not constricted.

The upper surface of the leaf opposite the strome is marked by a small, dark colored depression.

DISCOMYCETES.

PHIALEA AMPLA E. & E.

On decaying wood of *Salix*, Mt. Paddo, Wash. (Suksdorf, no. 493.)

Gregarious, stipitate, obconic, or clavate at first, at length expanding, 3–4 mm. in diameter, and shallow cup-shaped; disk lemon-yellow, outside paler, farinose-pubescent or minutely striate,

margin involute and entire; stipe stout, 1–2 mm. long, generally, in the mature plant, less than the diameter of the cup; asci clavate cylindrical, 110 × 6 μ; paraphyses filiform; sporidia uniseriate, overlapping, narrow, obovate, hyaline, 11–12 × 3½–4 μ.

Differs from *Helotium citrinum*, in its involute margin and larger size.

CENANGIUM ALBOATRUM E. & E.

On a decorticated decaying chestnut log, Nuttallburg, West Virginia, Jan., 1896. (L. W. Nuttall, no. 788.)

Gregarious, obconical, short-stipitate, closed at first, then discoid-plane, ¾–1 mm. in diameter, hymenium slate-color with a narrow white margin, finally dark throughout; asci clavate, short-stipitate, 35–45 × 6 μ; paraphyses linear; sporidia subuniseriate, ovate-elliptical, hyaline, continuous, 3–4 × 2–2½ μ.

Differs from the usual type of *Cenangium* in its scattered growth.

CENANGIUM TRYBLIDIOIDES E. & E.

On decorticated *Salix*, Mt. Paddo, Washington., alt. 7000 feet. (Suksdorf, no. 482.)

Gregarious, sessile, black, glabrous, of fibrous texture, laterally compressed, about 1 mm. long, lips incurved, margin whitish or faintly transversely rugulose; hymenium pallid; asci clavate-cylindrical, stipitate, 55–60 × 8 μ, paraphysate, 8-spored; sporidia oblong or oblong-elliptical, hyaline, continuous, 6–10 × 2½–3 μ, slightly curved, suballantoid.

LASIOBELONIUM SUBFLAVIDUM E. & E.

On wood of *Salix*, Mt. Paddo, Wash. alt. 7000 ft. (W. N., Suksdorf, no. 489.)

Scattered, short-stipitate, between light yellow and brick color, closed and clavate and light yellow at first, then open, shallow cupshaped, 1–1½ mm. across, of fibrous texture, clothed with appressed hairs and margin fimbriate with brown sparingly septate hairs 2–2½ μ thick; asci slender, clavate-cylindrical, 85–95 × 6 μ; paraphyses filiform; sporidia fusoid, hyaline, slightly curved, not constricted, 15–20 × 2–2½ μ.

SCHIZOXYLON MICROSTOMUM E. & E.

On dead stems of *Andromeda ligustrina*, Newfield, N. J., April, 20, 1896.

Ascomata scattered or gregarious, conic-papilliform, orbicular or subelliptical, 1–1¼ mm. in diameter, at first covered by the pus-

tuliform-elevated epidermis, then suberumpent exposing the small (½ mm.) black circular disk with a slightly raised paler margin; asci cylindrical, 250 × 12–14 μ, abruptly contracted at base into a short stipe and surrounded by abundant filiform branching paraphyses; sporidia cylindrical, hyaline, fasciculate, nearly as long as the asci, readily separating into cylindrical 3–6-septate segments, 10–20 (exceptionally 30) × 3½ μ, more or less constricted at the septa.

This has the general appearance of *Didymosphaeria grumata* Cke.

New Species of Fungi.

By Chas H. Peck.

Amanita candida.

Pileus thin, broadly convex or nearly plane, verrucose with numerous small erect angular or pyramidal easily separable warts, often becoming smooth with age, white, even on the margin, flesh white; lamellae rather narrow, close, reaching to the stem, white; stem solid, bulbous, floccose-squamose, white, the annulus attached to the top of the stem, becoming pendent and often disappearing with age, floccose-squamose on the lower surface, striate on the upper, the bulb rather large, ovate, squamose, not margined, tapering above into the stem and rounded or merely abruptly pointed below; spores elliptical, .0004 to .0005 in. long, .0003 in. broad. Pileus 3 to 6 in. broad; stem 2.5 to 5 in. long, 5 to 8 lines thick, the bulb 1 to 1.5 in. thick in the dried specimens.

Woods. Auburn, Alabama. October. L. M. Underwood and F. S. Earle.

This is a fine large species related to *A. solitaria*, but differing from it in the character of its bulb and of its annulus. The bulb is not marginate nor imbricately squamose. Its scales are small and numerous. Nor is it clearly radicating, though sometimes it has a slight abrupt point or mycelioid-agglomerated mass of soil at its base. The veil or annulus is large and well developed, but it is apt to fall away and disappear with age. Its attachment at the very top of the stem brings it closely in contact with the lamellae of the young plant and the striations of its upper surface appear to be due to the pressure of the edges of these upon it. It separates readily from the margin of the pileus and is not

lacerated. In the mature plant the warts have generally disappeared from the pileus and sometimes its margin is curved upward.

AMANITA ABRUPTA.

Pileus thin, broadly convex or nearly plane, verrucose with small angular or pyramidal erect somewhat evanescent warts, white, slightly striate on the margin, flesh white; lamellae moderately close, reaching the stem and sometimes terminating in slightly decurrent lines upon it, white; stem slender, glabrous, solid, bulbous, white, the bulb abrupt, subglobose, often coated below by the white persistent mycelium, the annulus membranous, persistent; spores broadly elliptical or subglobose, .0003–.0004 in. long, .00025–.0003 broad. Pileus 2–4 in. broad; stem 2.5–4 in. long, 3–4 lines thick.

Woods. Auburn, Alabama. July. Underwood.

The chief distinguishing mark of this species is its abrupt nearly globose bulbous base of the stem. This is somewhat flattened above and is sometimes longitudinally split on the sides. The small warts of the pileus are easily separable, and in mature specimens they have often wholly or partly disappeared. The remains of the volva are not present on the bulb in mature dried specimens, which indicates that the species should be placed in the same group with *A. rubescens*, *A. spissa*, etc. The latter species has the bulb of the stem similar to that of our plant, but the color of the pileus and other characters easily separate it.

AMANITA PRAIRIICOLA.

Pileus thin, convex, slightly verrucose, white, more or less tinged with yellow, even on the margin, flesh white; lamellae rather broad, subdistant, reaching the stem, white; stem equal or slightly tapering upward, somewhat squamose toward the base, white or whitish, the annulus persistent; spores large, broadly elliptical, .0005–.00055 in. long, .0003–.00035 broad. Pileus 1.5–3 in. broad; stem 2–2.5 in. long, 2–4 lines thick.

Bare ground on open prairies. Kansas. September. E. Bartholomew.

This species belongs to the same tribe as the preceding one. The only evidence of the presence of a volva shown by the dried specimens is found in a few inconspicuous, but separable warts on the pileus. There is no well marked bulb to the stem and no evident remains of a volva at its base.

LEPIOTA SUBLILACEA.

Pileus thin, convex, obtuse or umbonate, dry, floccose-squamulose, brownish tinged with lilac, flesh white; lamellae rather broad, free, subdistant, whitish; stem short, solid, colored like the pileus, but paler at the top, the annulus slight, evanescent; spores elliptical, .0004 in. long, .0002 broad, commonly containing a single large shining nucleus. Pileus 6–12 lines broad; stem 6–12 lines long, 1–2 lines thick.

Bare ground in pastures. Kansas. September. Bartholomew.

This plant appears to have some points of resemblance to *L. lilacea*, from which it may be separated by its solid stem and larger spores.

TRICHOLOMA ACRE.

Pileus fleshy, but rather thin, broadly convex, nearly plane or even slightly depressed in the center, often wavy on the margin, dry, innately fibrillose, whitish or pale gray, flesh white or whitish, taste acrid; lamellae close, adnexed, subventricose, white; stem equal or slightly tapering downward, short, slightly fibrillose, stuffed or hollow, white; spores subglobose, .0002–.00025 in. long, .00016–.0002 broad. Pileus 1.5–2.5 in. broad; stem 1–2 in. long, 3–5 lines thick.

Thin woods of deciduous trees. Worcester, Massachusetts. October. Dr. G. E. Francis.

The species is closely related to the European *T. impolitum*, from which it appears to differ in its paler pileus not becoming rimose-squamose, and in its stem, which is not at all squamose and which is stuffed or hollow rather than solid. Besides, its taste is only hot or peppery and not at all salty as in that species.

TRICHOLOMA PALLIDUM.

Pileus fleshy on the disk, thin towards the margin, convex or nearly plane, obtuse, glabrous, sometimes obscurely spotted on the disk with thin appressed brownish squamules, somewhat shining, whitish tinged with yellow or brownish-yellow, flesh white, sometimes slowly assuming a faint pinkish hue where cut or broken, taste mild; lamellae broad, subdistant, rounded behind or adnexed, often eroded on the edge, white; stem equal or slightly thickened at the base, glabrous, white; spores elliptical, .0002–.00025 in. long, .00016 broad. Pileus 1–2.5 in. broad; stem 1–2 in. long, 3–6 lines thick.

Thin wood of deciduous trees. Worcester, Massachusetts. October. Francis.

ARMILLARIA APPENDICULATA.

Pileus broadly convex, glabrous, whitish, often tinged with ferruginous or brownish-ferruginous on the disk, flesh white or whitish; lamellae close, rounded behind, whitish; stem equal or slightly tapering upward, solid, bulbous, whitish, the veil either membranous or webby, white, commonly adhering in fragments to the margin of the pileus; spores subelliptical, .0003 in. long, .0002 broad. Pileus 2–4 in. broad; stem 1.5–3.5 in. long; 5–10 lines thick.

Auburn, Alabama. October. C. F. Baker.

The general appearance of this species is suggestive of *Tricholoma album*, but the presence of a veil separates it from that fungus and places it in the genus *Armillaria*. The veil, however, is often slight lacerated or webby and adherent to the margin of the pileus.

CLITOCYBE TARDA.

Pileus fleshy but rather thin, easily splitting when old, but firm when young and fresh, convex becoming nearly plane or somewhat centrally depressed, sometimes slightly umbonate, glabrous, hygrophanous, brown when moist, grayish or grayish-brown when dry, the margin at first deflexed or incurved, flesh white, inodorous; lamellae subhorizontal, moderately close, rather fragile, adnate or slightly decurrent, often eroded on the edge, at first with a pale violaceous tint, becoming whitish; stem short, equal or tapering downwards, solid, fibrillose, colored like the pileus; spores elliptical, .0003 in. long, .00016 broad. Pileus 1–3 in. broad; stem about 1 in. long, 1–3 lines thick.

Ground in greenhouses. Lynn, Massachusetts. December. Mrs. A. P. Doughty.

The species is referable to the second section of the tribe Orbiformes. The stem, when viewed by the aid of a lens, appears to be longitudinally and interruptedly rimulous from the separation of the fibrils. These are somewhat reticulately connected as in the stem of *C. cyathiformis*. The lamellae easily split transversely, and sometimes separate from the pileus at their inner extremity.

There are two forms. The darker colored one may be taken as the typical form. It is firmer, more regular, and under a lens sometimes appears to be minutely innately fibrillose. The other may be designated as

CLITOCYBE TARDA PALLIDIOR.

Pileus paler, more fragile and irregular, more apt to be cen-

trally depressed, somewhat striate on the margin when dry, sometimes eccentric; lamellae of the young plant with a flesh-colored tint.

The species is separated from *C. diatreta* by its darker and differently colored pileus and by its solid stem.

HYGROPHROUS CUSPIDATUS.

Pileus thin, subcampanulate, glabrous, cuspidate, bright red; lamellae broad, ventricose, yellow; stem slender, equal, glabrous, hollow; spores elliptical, .00045–.0006 in. long, .00025–0003 broad. Pileus 6–10 lines broad; stem 1–2 in. long, about 1 line thick.

Ottawa, Canada. September. J. Macoun.

This fungus is closely allied to *H. conicus*, of which it might easily be taken to be a variety, but its more slender habit, its strongly cuspidate pileus and its longer and comparatively more narrow spores lead me to separate it. As in that species the plants are apt to turn more or less black in drying.

COLLYBIA LUXURIANS

Pileus thin, convex or subcampanulate, often irregular from its mode of growth, obtuse or umbonate, glabrous, moist, brown; lamellae narrow, close, whitish; stems caespitose, equal, flexuous, hollow, brown, thinly clothed above with a minute grayish pulverulent villosity which is often more dense and tomentose toward the base; spores elliptical, .00025–.0003 in. long, .00016 broad. Pileus 2–4 in. broad; stem 3–4 in. long, 2–3 lines thick.

Under brush heaps. Auburn, Alabama. July. Underwood.

This is a large caespitose and luxuriant appearing species, but as the specimens were not accompanied by notes of the characters of the fresh plant it can only be imperfectly described. The pileus was said to be very moist when fresh and it was probably hygrophanous. In the dried state it is a dull, reddish brown, closely approaching Mars' brown. Its margin is more or less wavy, lobed and striate. The species is apparently related to *C. confluens*, but it is a much larger plant with a darker colored pileus. Its place is probably among the Confertipedes.

OMPHALIA PUBESCENTIPES.

Pileus thin, convex, umbilicate, glabrous, reddish-tawny, sometimes paler on the margin; lamellae moderately close, decurrent, whitish; stem slender, pubescent, tawny with a tawny mycelioid tomentum at the base; spores elliptical, .00025 in. long, .00016 broad. Pileus 2–4 lines broad; stem about 1 in. long, .5 line thick.

Decaying wood and vegetable mold. Alabama. December. Earle.

The downy or pubescent stem is the distinguishing character of this species.

Marasmius plicatulus.

Pileus submembranous, convex or subcampanulate, glabrous, even when moist, commonly sulcate or striate when dry, dark vinous red inclining to bay brown; lamellae subdistant, narrowed behind, adnexed, whitish; stem slender, hollow, glabrous above, shining, blackish-brown, red at the top, radicating and clothed at the base with a copious dense whitish villosity or tomentum; spores subelliptical, apiculate at one end, somewhat narrowed toward the other, .0004–.0005 in. long, .0002–.00025 broad. Pileus 6–12 lines broad; stem 2.5–5 in. long, about 1 line thick.

Among fallen leaves and other decomposing vegetable matter. Common in Southern California. A. J. McClatchie.

The colors of this plant are very similar to those of *Marasmius pulcherripes*, but it is a much larger plant and differs in the attachment of its lamellae and in the character of the base of the stem. In the dried specimens the stem is striate and the pileus has a velvety appearance, but it is glabrous.

I find that the name *Marasmius badius*, Bull. Torr. Club, **22**: 487, 1895, was preoccupied and I would substitute for it Marasmius badiceps.

Flammula edulis.

Pileus fleshy, convex, obtuse, glabrous, moist, brown, grayish-brown or alutaceous-brown, sometimes rimose, flesh whitish; lamellae rather broad, close, decurrent, bright tan color, becoming brownish-ferruginous; stems caespitose, equal, stuffed or hollow, brown; spores subelliptical, .0005 in. long, .0002–.00025 broad. Pileus 2–3 in. broad; stem 2–3 in. long, 3–6 lines thick.

Grassy ground, along pavements, in gutters and by the side of wooden frames of hotbeds. Haddonfield, New Jersey. October. C. McIlvaine.

The collector of this species informs me that the flavor of the fresh plant is slightly bitter, but that this disappears in cooking and the fungus furnishes a very good and tender article of food. Successive crops continued to appear for a month. In the dried specimens the stem is striate.

Galera angusticeps.

Pileus thin, narrowly and irregularly conical or subcylindrical, obtuse acute or abruptly acuminate at the apex, even, glabrous, viscid and dark ochraceous when young and moist, nearly white when old and dry, the margin somewhat incurved and appressed to the stem; lamellae close, narrow, adnate, somewhat white-margined, more or less anastomosing, brownish-ferruginous when mature; stem slender, glabrous, hollow, equal or slightly thickened at the base, whitish or tinged with yellow, shining when dry; spores elliptical, .0004–.0005 in. long, .0003 broad. Pileus 8–15 lines long, 4–6 lines wide; stem 1.5–3 in. long, 1–1.5 lines thick.

Grassy ground in streets and pastures. Pasadena, Los Angeles and Compton, California. McClatchie.

This species is closely allied to *G. lateritia* and *G. semilanceata*, from both of which I have separated it because of its viscid pileus the absence of striations and the darker color of its mature lamellae. The pileus also scarcely expands, so far as shown by the specimens seen, and the notes of the collector say that the margin is "permanently incurved."

Galera alba.

Pileus submembranous, campanulate, very fragile, moist, striate, splitting on the margin, white; lamellae narrow, close, white, becoming brownish-ferruginous; stem fragile, hollow, glabrous, white; spores elliptical, .0005–.0006 in. long, .0003–.0004 broad, commonly containing one to three nuclei. Pileus 8–12 lines broad; stem 1.5–2.5 in. long, 1–2 lines thick.

Rich ground in the shade of weeds. Brookings, South Dakota. Summer. T. A. Williams.

It occurs after rains in warm weather. It is more fragile when fresh than when dried.

Galera versicolor.

Pileus thin, fragile, convex or subcampanulate, moist or slightly viscid, glabrous, striate on the margin, whitish pale-yellow or brownish tan color; lamellae close, white or pale yellow, becoming reddish-ferruginous; stem equal, fragile, hollow, slightly mealy or pruinose, often tomentose at the base, white; spores very unequal in size, .0005–.0008 in. long, .0003–.0005 broad, generally containing one to three nuclei. Pileus 1–2.5 in. broad; stem 2–4 in. long, 1–2 lines thick.

Manure and other decaying vegetable matter. Brookings, South Dakota. Spring and early summer. Williams.

The species is remarkable for the variability in the color of the pileus and in the size of the spores. These vary in the same individual. The prevailing color of the pileus is pale yellow.

GALERA FRAGILIS.

Pileus submembranous, very fragile, broadly campanulate, glabrous, dull flesh color; lamellae ascending, adnate, subdistant, dark yellow or subochraceous, becoming ferruginous; stem slender, flexuous, hollow; spores elliptical, .0004 in. long, .0002 broad. Pileus 3–5 lines broad; stem 10–15 lines long, .5 line thick.

Among short grasses in pasture. Kansas. Bartholomew.

A very small and very fragile plant.

PSILOCYBE SABULOSA.

Pileus convex, subumbonate, glabrous, yellow; lamellae broad, subdistant, ventricose, adnate, becoming purplish-brown, whitish on the edge; stem equal, hollow, pallid or straw-color; spores elliptical, .0005–.0006 in. long, .0003 broad. Pileus 8–12 lines broad; stem 1–1.5 in. long, about 1 line thick.

Sandy soil in pastures. Kansas. August. Bartholomew.

The pileus in the dried specimens has a somewhat shining appearance. The umbo in some specimens is quite prominent, in others it is wholly wanting. The species is quite distinct from *P. arenulina*, which is hygrophanous and has smaller spores.

PSILOCYBE OBSCURA.

Pileus thin, convex, hygrophanous, striate, more or less flecked or scurfy with a white floccose tomentum, brown or reddish-brown; lamellae broad, subdistant, adnate, brown, becoming almost black, white flocculent on the edge; stem slender, hollow, a little paler than the pileus, whitish tomentose at the base; spores elliptical, .0004–.0005 in. long, .00025–.0003 broad. Pileus 4–9 lines broad; stem 1–1.5 in. long, about 1 line thick.

Rich leaf mold in woods. Kansas. August. Bartholomew.

BOLETUS FISTULOSUS.

Pileus convex, viscid, glabrous, yellow, the margin at first incurved or involute, flesh yellow; tubes plane or subventricose, medium size, round with thin walls, adnate or sometimes depressed around the stem, yellow; stem rather slender, subequal, viscid, glabrous, hollow, yellow, with a white mycelioid tomentum a the base; s res elliptical, .0005 in. long, .00025 broad. Pileus about 1 in. b ad; stem 2–4 in. long, about 3 lines thick.

Grassy woods. Auburn, Alabama. July. Underwood.

A small but pretty species of a yellow color throughout. It is remarkable for its hollow stem, which is suggestive of the specific name. It is referable to the tribe Viscipelles.

BOLETUS FRATERNUS.

Pileus convex, becoming plane or depressed, slightly tomentose, deep red when young, becoming dull red with age, flesh yellow, slowly changing to greenish-blue where wounded; tubes rather long, becoming ventricose, slightly depressed about the stem, their walls sometimes slightly decurrent, the mouths large, angular or irregular, sometimes compound, bright yellow, quickly changing to blue where wounded; stem short, caespitose, often irregular, solid, subtomentose, slightly velvety at the base, pale reddish yellow, paler above and below, yellow within, quickly changing to dark green where wounded; spores .0005 in. long, .00025 broad. Pileus 1–1.5 in. broad; stem 1–1.5 in. long, 3–6 lines thick.

Shaded streets. Auburn, Alabama July. Underwood.

The species is apparently allied to *R. rubeus*, but is very distinct by its small size, caespitose habit, color of the flesh of the stem and by the peculiar hues assumed where wounded. When the pileus cracks the chinks become yellow as in *B. subtomentosus*. The species belongs to the tribe Subtomentosi.

BOLETUS UNDERWOODII.

Pileus rather thin, convex, becoming nearly plane, slightly velvety, bright brownish-red, becoming paler with age, flesh yellow, changing to greenish-blue where wounded; tubes adnate or slightly decurrent, greenish-yellow, becoming bluish where wounded, their mouths very small, round, cinnabar red, becoming brownish orange; stem equal or slightly tapering upward, somewhat irregular, solid, yellow without and within; spores .0004–.0005 in. long, .0002 broad. Pileus 2–3 in. broad; stem 3–4 in. long, 4–6 lines thick.

Grassy woods. Auburn, Alabama. July. Underwood.

The species is remarkable for its adnate or subdecurrent tubes in which it departs from the character of the tribe to which it belongs according to the colors of the tubes.

BOLETUS PARVUS.

Pileus convex, becoming plane, often slightly umbonate, subtomentose, reddish, flesh yellowish white, slowly changing to

pinkish where wounded; tubes nearly plane, adnate, their mouths rather large, angular, at first bright red, becoming reddish-brown; stem equal or slightly thickened below, red; spores oblong, .0005 in. long, .00016 broad. Pileus 1–2 in. broad; stem 1–2 in. long, 2–3 lines thick.

Grassy woods. Auburn, Alabama. July. Underwood.

This is one of the smallest species of the tribe. It is referable to the tribe Luridi.

BOLETUS FRUSTULOSUS.

Pileus thick, convex or nearly plane, subglabrous, rimosely areolate, white or whitish, flesh whitish; tubes equal to or a little longer than the thickness of the flesh of the pileus, depressed about the stem, whitish, becoming pale brown; stem equal, solid, whitish, reticulated above; spores .0006–.0007 in. long, .0002–.00025 broad. Pileus 3–5 in. broad; stem 1–2 in. long, 6–10 lines thick.

Open ground and clay banks. Ocean Springs, Mississippi and Akron, Alabama. May and June. Underwood.

The deeply cracked surface of the pileus is the most notable feature of this species. This sometimes is seen even in quite young plants. The areolae are quite unequal in size. The deep chinks with sloping sides cause them to appear like frustra of polygonal pyramids. In some specimens the reticulations of the stem extend nearly or quite to its base, and make the place of the species ambiguous between the Calopodes and Edules.

BOLETUS ISABELLINUS.

Pileus convex, firm, minutely tomentose, whitish, becoming darker and smoother with age, flesh isabelline; tubes adnate, minute, sometimes larger near the stem, nearly round, whitish; stem nearly equal, subglabrous, hollow, whitish; spores subelliptical, .0003–.00035 in. long, .0002–.00025 broad. Pileus 2–3 in. broad; stem 1–2 in. long, 4–6 lines thick.

Woods. Ocean Springs, Mississippi. June. Underwood.

The species belongs to the Cariosi.

POLYPORUS BURTII.

Pileus dimidiate, 1–2 in. broad, tough, sessile or effuso-reflexed, minutely tomentose, smoky whitish or pallid, flesh 1–2 lines thick, pallid; pores .5–1 line long, unequal, angular, extending to the margin, smoky black, their dissepiments thin.

Yellow birch, *Betula lutea*. Middleburg, Vermont. December. E. A. Burt.

This fungus is closely allied to *Polyporus adustus*, of which it might easily be considered a mere variety, but from which it differs as *P. fragrans* does from *P. fumosus*. Its unequal angular pores with thin dissepiments and the absence of a sterile margin to the pileus separate it from *P. adustus*. Its colors are nearly the same as in that species.

CRYPTOPHALLUS *gen. nov.*

Receptacle consisting of a stem and pileus bearing the gleba on its external surface but covered by the persistent remains of the upper part of the volva.

A genus of Phalleae differing from *Ithyphallus* simply in having a volva which ruptures in a somewhat circumscissile manner, the upper part of it being carried up and remaining on the pileus and persistently concealing the stratum of spores.

It is with some hesitation that I have given generic value to this plant, it seemed at first so probable that the persistency of the remains of the volva on the pileus was an accidental circumstance. But having received two specimens of the same kind, one collected in Kansas and the other in Canada, the probability of its being a mere accident seemed greatly lessened and I have concluded to recognize the fact in a formal manner. The sporiferous stratum is sandwiched between the surface of the pileus and the continuous covering formed by the remains of the volva. What purpose in nature is subserved by this arrangement is not clear, except that perhaps the spores are less exposed to the rapid and sudden washing of heavy rains and are better reserved for dissemination and dispersion by the agency of insects.

CRYPTOPHALLUS ALBICEPS.

Pileus subcampanulate, about one inch high and nearly as broad, obtuse or rounded at the apex, covered by the whitish remains of the ruptured volva whose surface is minutely tomentose; stem cylindrical, hollow, 2½–4 in. long, 5–8 lines thick, whitish or pallid, inserted at the base in the cup-like remains of the lower part of the volva; veil none; spores narrowly elliptical, .00016–.0002 in. long, about .0001 broad.

In a cornfield. Kansas. June. Bartholomew. At the base of a stump. Canada. J. Macoun.

The species is similar to *Ithyphallus impudicus*, except in the covering of the pileus.

Studies in the Flora of the Central Gulf Region.—I.

By Charles Louis Pollard.

The Central Gulf Region, comprising the States of Alabama and Mississippi, has been neglected by collectors to an extent that is surprising in view of the interest attaching to its flora; a condition of affairs, doubtless due to the fact that Professor S. M. Tracy and Dr. Charles Mohr, both zealous field workers, have been most generous in supplying material for investigation. In the course of several months' study of Mississippi and Alabama *Cassias*, I had observed that in these southern specimens, as well as in Florida material, there was apt to be uniform variation from northern types as I understand them. With the object, therefore, of supplementing herbarium work by field observations, I spent a month in Mississippi during the past summer, for the most part exploring the Gulf coast, although some time was put in at Waynesboro, near the northern limit of the pine belt and at the Agricultural College, on the northeastern quarter of the State. During this visit over four hundred plants were collected, and I have since been afforded the opportunity of examining the collections made later in the summer, throughout substantially the same area, by Mr. T. H. Kearney, of the Department of Agriculture, to whom I am greatly indebted. Mr. Charles Schuchert, of the National Museum, made a collection of plants late in the fall, in the neighborhood of Meridian and Waynesboro, Mississippi, and in adjacent portions of Alabama; these specimens, which are of great interest as containing a number of the characteristic fall composites, Mr. Schuchert kindly turned over to me, and they will be reported upon in a subsequent paper. Professor S. M. Tracy, of the Mississippi Agricultural Experiment Station, also placed in my hands a large number of specimens obtained in every quarter of the State, and for these, as well as for his many kindnesses and cordial hospitality, I would return sincerest gratitude. I have thus been enabled to examine a large portion of the known flora of Mississippi and to verify, by actual observations in the field, a number of conclusions previously drawn.

Probably the most conspicuous, and certainly the most interesting feature of this flora, is the extension of types from the

Florida peninsula westward along the Gulf coast. It is a common experience to find in southern Mississippi, for example, a plant which, according to Dr. Chapman's work, is an exclusive inhabitant of south Florida; and it is quite as often that species actually assigned to Mississippi do not match the characters given for them in the book. These circumstances serve to emphasize the necessity for much critical field work in this area, and a careful study of southern species in the light of modern taxonomic principles.

The following notes are based on my own collections, the first set of which is deposited in the United States National Herbarium, the remainder having been already distributed. The determinations of the Gramineae were made by Professor Tracy, and of the Cyperaceae by Dr. N. L. Britton, to whom I would extend thanks, as also to Dr. J. K. Small, Mr. Frederick V. Coville, Dr. J. N. Rose, Professor L. M. Underwood, Mr. P. A. Rydberg, Mr. G. B. Sudworth, and Dr. G. N. Best, for their courtesy in naming certain groups.

ADIANTUM CAPILLUS-VENERIS L.

This beautiful fern was found for the first time in Mississippi, as far as I have been able to ascertain, at Waynesboro, Wayne County, near the Alabama line. On my arrival at the village I at once observed it growing in pots and hanging baskets about the veranda of the hotel, and supposed it had been brought from some distance; but inquiry elicited the fact that the locality was only a few miles away, and the son of my good landlady, a young man whose knowledge of local plant-names is very extensive, readily volunteered his services as guide. The fern grew on the steep banks of the creek, in rather damp soil, the fronds for the most part pendent, and growing so dense that other vegetation was entirely excluded.

STIPULICIDA SETACEA Michx.

A single specimen was obtained on Deer Island, in Biloxi Bay, and others were observed; the range is thus extended consideraby westward.

ASIMINA PARVIFLORA (Michx.) Dunal.

One specimen, with nearly ripe fruit, was collected at Waynes-

boro, but Prof. Tracy kindly furnished me with additional material obtained by him in the previous spring at Columbus, in the northern part of the State.

CASSIA MULTIPINNATA Pollard, Bull. Torr. Club, 22: 515. 1895.

This species, together with the low, diffuse *C. multipinnata Nashii*, is the only small-flowered *Cassia* in the coast region, as it is in Florida. I visited the type locality for *C. Mississippiensis** near Ocean Springs, but the extremely abundant form mistaken by Prof. Tracy for this species proved to be beyond question *multipinnata*. The distinguishing feature of the latter is found in its very numerous and exceedingly narrow leaflets. In travelling northward through the state, we find that the *multipinnata* belt overlaps the belt of the true *nictitans*, and occasionally specimens of evident hybrids may be collected. In the mountains of northern Alabama, Dr. Mohr has found typical *nictitans*, but it barely enters Mississippi.

The late-blooming feature of *multipinnata* was again observed. At the time of my departure from the State on August 20, no trace of a flower could be detected on any of the plants examined, although here in Washington at the same time the seed-pods of *nictitans* were rapidly maturing. Prof. Tracy supplied flowering specimens of *multipinnata* from Starkville on September 1, and from Biloxi on September 15. (Nos. 1349 and 1422.)

CASSIA DEPRESSA Pollard, Bull. Torr. Club, 22: 515. 1895.

This occurs in some abundance along the coast, blooming in September. (No. 1423.) *C. Chamaecrista* is not common until the interior is reached, but abounds everywhere northward, being at its prime in August.

CASSIA ROBUSTA Pollard.

Cassia Chamaecrista robusta Pollard, Bull. Torr. Club, 21: 219. 1894.

The type of this species is a specimen in the herbarium of Columbia University, collected by Dr. C. W. Short in the mountains of Kentucky. It is without fruit, and I did not at the time feel warranted in giving it more than varietal rank. Last year a plant similar in appearance was sent me by Professor Tracy, bear-

* Bull. Torr. Club, 21: 219. 1894.

ing mature pods which at once attracted attention by their recurved position. I cultivated garden specimens from seeds of this plant, and when in Mississippi visited the locality whence it was originally obtained. Not having access to my former type, and appreciating its distinctness from *Chamaecrista* I gave a partial diagnosis of it as a new species in a note presented before Section G at the Buffalo meeting of the Association. The plant must, of course, assume the varietal name originally assigned to it. (No. 1276.)

CASSIA ASPERA MOHRII Pollard, n. var.

Aspect of *C. aspera:* hispid pubescence and leaflets as in that species, except that both surfaces of the leaflets are hoary with stiff white hairs; petiolar gland depressed-cupuliform, substipitate.

Type in the herbarium of the U. S. Geol. Surv. of Alabama, collected in Mobile in 1878 by Dr. Mohr, to whom the variety is dedicated.

PHASEOLUS SINUATUS Nutt. T. & G. Fl. N. Am., 1:279. 1838.

Specimens of this were obtained, not yet in flower, near Ocean Springs. (No. 1017.) I have not been able to find a previous record of its appearance west of Florida.

DAUBENTONIA LONGIFOLIA (Cav.) DC. Mem. Legum. 285. 1825.

The discovery of a plant on the coast of Mississippi (No. 1001) hitherto known only from Texas and Mexico, and as a ballast immigrant at Pensacola, Florida, is of interest as illustrating the tendency of the western gulf flora to move eastward, just as the Florida peninsula flora in so many cases exhibits a northwestward extension. While undoubtedly originally introduced, this showy plant now figures prominently along the sea-beach at Biloxi and other coast towns, and with its large, bright yellow flowers and four-winged, many-seeded pods, ought never to be mistaken for the nearly-related *Glottidium Floridanum*, which grows in the same region. The characters of the legume separate *Daubentonia* and *Glottidium* from *Sesbania* fully as clearly as similar characters distinguish any Mimosaceous genera. In *Sesbania* we have a pod which is narrow, elongated, tetragonal, and many-seeded, usually torulose. *Glottidium* has a short compressed pod, two-seeded,

with a thick, coriaceous epicarp splitting away at maturity from the membranous endocarp, which remains investing the seeds. *Daubentonia* has a several-seeded, compressed and often torulose legume, the central portion of the winged vaives becoming indurated over the seeds, and hence never dehiscent.* A more striking contrast of characters in a group of nearly related genera it would be hard to find elsewhere in the Leguminosae.

The bibliography of the species is involved in some obscurity, owing to the fact that all copies in this country of one of the works concerned, Ortega's Hortus Matritensis, are apparently incomplete, and to the resultant fact that the synonymy has been thrown into confusion by later writers. The genus *Daubentonia* was based by De Candolle upon *AEschynomene longifolia* Cav., and *Piscidia punicea* Cav. Reference to the latter's work shows the plate of *A. longifolia* to be an excellent and unmistakable reproduction of our Texano-Mexican plant.

In addition to the two species of *Daubentonia*, De Candolle describes in Prodromus 2 : 265 a species of *Sesbania* under the name of *S. longifolia*, for which he cites as a synonym Ortega's *AEschynomene longifolia*, referring to the plate of the latter in the ninth decade of the Hortus. In his characterization of the species he uses the words " leguminibus linearibus torulosis acutis," which cannot apply to anything but a true *Sesbania*. It is thus evident that De Candolle understood with great clearness tne fact that Ortega and Cavanilles had described two different plants under the same binomial appellation (*AEschynomene longifolia*), the former of which he transferred to *Sesbania*, and the latter he raised to generic rank; by this means he preserved the same specific for each. It is due to the efforts of later botanists to combine both forms under *Sesbania* that most of the trouble has originated. Among British authorities, especially, there has been a surprising tendency to jump at conclusions, and, as it would seem, to avoid the proper verifications of references, since a very superficial examination of the pages above cited would have afforded a solution.

The genus *Daubentonia* is taken up by Torrey and Gray, and the citations are correctly given.† On the other hand, Hemsley,

* For a good figure of this type of legume, see Fig. 117, Engl. & Prantl. Nat. Pflanzenf. Theil 3: 279, 1894, under *Sesbania punicea*.

† Torr. & Gray, Fl. N. Am. 1 : 294. 1838.

in Vol. I, p. 263, of the Biologia Centrali-Americana, enumerates *Sesbania longifolia* DC., with its synonym *AEschynomene longifolia* Ortega, but refers, for an example, to Parry and Palmer's No. 209, from Central Mexico, which is beyond question *Daubentonia*. No mention whatever is made of Cavanilles' plate, and we are forced to conclude that Mr. Hemsley imagined the two species to be identical. Dr. Watson appreciated this error, and remarks* "*Sesbania Cavanillesii* Watson, *Daubentonia longifolia* DC., * * * No. 209, Parry and Palmer belongs to this species, not to *S. longifolia* DC., which, according to the description is very different." The Index Kewensis makes matters worse, as follows:

AEschynomene longifolia Cav. Icon. 4: 8. *t. 316.*=*Piscidia longifolia.*

AEschynomene longifolia Orteg. Hort. Mat. Dec. 9: 70.=*Sesbania Cavanillesii.*

This is most remarkable when we recollect the fact that both the synonyms cited belong exclusively to the *AEschynomene* of Cavanilles, not to that of Ortega, which should, of course, have been referred to *Sesbania longifolia* DC., a name admitted by the Index in another place, as that of a valid pecies.

In Coulter's Botany of Texas† appears a very good diagnosis of our plant under Watson's name, *Sesbania Cavanillesii*. It is there quoted as "abundant on the lower Rio Grande and also near San Antonio." Specimens in the National Hebarium are as follows: Texas, Dr. Schlottman; Schott, 1853, Bravo del Norte; J. F. Joor, 1875, Harrisburg; Berlandier, no. 3132; Palmer, San Antonio, 1880, no. 278; Harvard, 1884; Nealley, 1889, no. 76; Florida, Pensacola, Curtiss, no. 590.

Specimens of *Sesbania longifolia* DC., are represented as follows: Guadalajara, Jalisco, Mexico, Palmer, no. 237, 1886; Pringle, no. 4738, 1894. These specimens are instantly recognizable as true *Sesbanias*, having linear torulose legumes and ovate-lanceolate leaflets.

It is, therefore, quite evident that whether these two species are regarded as congeneric or are separated, one of them must take a name other than *longifolia*, which belongs, by right of pri-

* Proc. Am. Acad. 17: 342. 1882.

† Contr. Nat. Herb. 2: 281. 1891.

ority to the plant of Cavanilles.* The Mexican plant must, therefore, take a new designation, and the synonymy and citation of the two species will then stand as follows:

SESBANIA MEXICANA nom. nov.

AEschynomene longifolia Orteg. Hort. Matr. Dec. 9: 70. 1800. Not Cav.

Sesbania longifolia DC. Prodr. 2: 265. 1825.

Mexico, state of Jalisco.

DAUBENTONIA LONGIFOLIA (Cav.) DC. Mem. Legum. 285. 1825.

AEschynomene longifolia Cav. Icon. 4: 8. *pl. 316.* 1797. Not Orteg.

Piscidia longifolia Willd. Sp. Pl. 3: 920. 1800.

Sesbania Cavanillesii S. Wats. Proc. Am. Acad. 17: 342. 1882.

Mexico and southern Texas along the Gulf coast to western Florida.

CLIFTONIA NITIDA Banks; Gaertn f. Fruct 3: 246. *pl. 225.* 1805.

Mylocaryum ligustrinum Willd. Enum. Hort. Berol. 454. 1809.

Cliftonia ligustrina Sims; Spreng. Syst. 2: 316. 1825.

A rare plant in many localities, but in Mississippi not uncommon on the coast. (No. 1040.)

KOSTELETZKYA VIRGINICA SMILACIFOLIA Chapm. Fl. S. States 57. 1860.

It is with some hesitation that I refer no. 1164 to this variety. The hastate leaves agree entirely with Dr. Chapman's description, but the flowers in my specimens are pure white. This plant, as well as typical *K. Virginica*, was obtained in the vicinity of Biloxi.

AMMANNIA COCCINEA Rottb. Pl. Hort. Havn. Descr. 7. 1773.

Specimens of unusual size were collected at the Agricultural College (No. 1309), and distributed erroneously as a new species of *Rotala*. The status of our American *Ammannias* is somewhat uncertain, owing to the ambiguity of the Linnaean *A. latifolia*. Dr. Koehne †has very properly distinguished two species, one with long style and capsule and fugacious petals, for which he adopts the

* The ninth decade of Ortega's work did not appear before 1800, as stated by De Candolle, whose reference I have not at hand.

† Engler's Bot. Jahrb. 1: 249–251. 1880.

name *coccinea* of Rottboell, and another of more southerly range with very short style and no petals, for which the name *latifolia* is taken up. The question yet in doubt, it seems to me, is whether the type of Linnaeus' species was really a short-styled plant. The only figure cited is from Hans Sloane's History of Jamaica, a work which I have been unable to examine. Dr. Britton has described still a third species.* *A. Koehnei*, which apparently combines the characters of the other two in having the petals of *coccinea* and the short style of *latifolia;* but it is by no means certain that this floral character is constant.

RHEXIA FLORIDANA Nash, Bull. Torr. Club, 2: 150. 1895.

Another illustration of the northwestward extension of the Florida flora. Typical specimens of this *Rhexia* were collected at Biloxi on July 29 (No. 1096), and were easily distinguishable by their narrowly linear leaves and the dark olive-green hue of the whole plant from the abundance of *R. Mariana* growing in the immediate vicinity.

RHEXIA LANCEOLATA Walt. Fl. Car. 129. 1788.

A species accepted by Torrey and Gray, but reduced by Cogniaux in his Monograph† to *R. Mariana*. The totally different color of the flowers, a feature of importance in this genus, as well as the glabrous calyx of *R. lanceolata*, points to its specific validity. Specimens were obtained at Ocean Springs (No. 1077).

HYDROCOTYLE BONARIENSIS Lam. Encycl. 3: 153. 1788.

Mr. J. N. Rose furnishes me with the following note on this rare species: "The collection of *Hydrocotyle Bonariensis*, a southern Mexican and South American species, in Mississippii is of interest. This species is entirely new to the United States, except that the variety *Texana* occurs in a single locality in southern Texas. It belongs, of course, near *H. umbellata*, and may sometimes be mistaken for that species. The inflorescence, however, is different, as *H. umbellata* usually has a simple umbel, while *H. Bonariensis* has numerous elongated rays with a number of interrupted whorls of flowers."

* Bull. Torr. Club, 18: 271. 1891.

† Cogn. in DC. Mon. Phan. 7: 388. 1891.

SABBATIA BRACHIATA Ell. Bot. S. C. & Ga. 1: 284. 1817.

It is quite possible that Michaux had this plant in mind as the type of his *Chironia angularis* var. *angustifolia*;* the description of the latter is too meagre, however, to warrant a change in the name without further research.

NERIUM OLEANDER L. Sp. Pl. 209. 1753.

Abundant on the beaches along the coast as an escape from gardens and in many places apparently spontaneous.

ASCLEPIAS VERTICILLATA LINEARIS (Scheele).

Asclepias linearis Scheele, Linn. 21: 758. 1848.

Asclepias verticillata var. *subverticillata* A. Gray, Proc. Am. Acad. 12: 71. 1876.

Only two specimens of this variety were obtained (no. 1006, Ocean Springs). It is distinguishable from the type by the opposite rather than verticillate leaves.

ASCLEPIAS AMPLEXICAULIS Michx.

Abundant in the sand on Deer Island, off the coast of Biloxi. (No. 1186). Walter's characterization of his *A. humistrata* as "floribus rubris" leads me to doubt the propriety of taking up his name for the species.

LEONOTIS NEPETAEFOLIA R. Br.

A tropical African plant sparingly adventive throughout the South, but in the coast region of Mississippi a common weed.

MESOSPHAERUM RUGOSUM (L.).

Clinopodium rugosum L. Sp. Pl. 588. 1753.

Hyptis radiata Willd. Sp. Pl. 3: 84. 1800.

This labiate is common in southern Mississippi. The genus *Mesosphaerum*, founded by Patrick Browne in 1756, has thirty years' priority over *Hyptis* of Jacquin.

TEUCRIUM NASHII Kearney, Bull. Torr. Club, 21: 484. 1894.

My specimens of this handsome *Teucrium*, collected on Prof. Tracy's grounds near Biloxi (no. 1075), exactly match Mr. Kearney's type from Florida.

* Fl. Bor. Am. 1: 146. 1803.

GRATIOLA HISPIDA (Benth.).

Sophronanthe hispida Benth.; Lindl. Intr. Nat. Syst. Ed. 2, 445. 1836.

Gratiola subulata Baldw.; Benth. DC. Prodr. 10: 405. 1846.

This little plant, which bears when growing an aspect similar to that of a small *Phlox*, was found in abundance on Deer Island (No. 1187). I am by no means convinced that a comparative study of the species of *Gratiola* will not justify Bentham's original segregation of *G. hispida* as a distinct genus.

RUELLIA HUMILIS Nutt. Trans. Am. Phil. Soc. (II.) 5: 182. 1833–7.

Ruellia ciliosa var. *longiflora* A. Gray, Syn. Fl. 2: Part 1, 326. 1878.

This species was found by Nuttall on the low, scarcely caulescent plant of which my number 1221, collected at Waynesboro, is representative. Specimens are in the National Herbarium obtained by Curtiss in Florida (no. 149), and also by Nash (no. 183) in the same State. Dr. Gray afterwards included it in his variety *longiflora* of *R. ciliosa* Pursh. The original description gives no warrant for applying the name *humilis* to the tall leafy plants that are known everywhere as typical *ciliosa*; and even in cases where the stem is more than usually elongated, the obovate obtuse leaves are always so distinguishable from the ovate more or less acute leaves of the latter species.

CARDUUS LECONTEI (T. & G.).

Cirsium Lecontei T. & G. Fl. N. Am. 2: 456. 1841.

Cnicus Virginianus Hook. Comp. Bot. Mag. 1: 48. 1835. Not Pursh.

A single specimen of this handsome species was collected in a moist pine barren near Ocean Springs.

CARDUUS NUTTALLII (DC.).

Cirsium Nuttallii DC. Prodr. 6: 651. 1837.

Cnicus glaber Ell. Bot. S. C. & Ga. 2: 270. 1824. Not *Carduus glaber* Nutt. Gen. 2: 129, 1818, nor Steud. Nom. Ed. 1, 152. 1821.

This species being exclusively southern in its range, it is probable that Nuttall's *Carduus glaber*, referred in his description to New Jersey, is a form of *C. muticus*.

STOKESIA LAEVIS (Hill) Greene, Eryth. 1: 3. 1893.

Carthamus laevis Hill, Hort. Kew. 57. *pl.* 5. 1769.

Stokesia cyanea L'Her. Sert. Angl. 27. 1788.

Cartesia centauroides Cass. Bull. Philom. 1816: 198. 1816.

This beautiful plant, usually considered the rarest of the Compositae, is extremely abundant along the whole length of the Mississippi coast, growing in dry or moist pine-barrens, and bearing a striking resemblance to a large *Aster*.

ERIANTHUS TRACYI Nash, Bull. Torr. Club, 24: 37, 1897.

A fine new species of *Erianthus*, collected only in a single locality in the vicinity of the Agricultural College, near Starkville. (No. 1341.)

Proceedings of the Club.

TUESDAY EVENING, FEBRUARY 9, 1897.

The President occupied the chair and there were about 200 persons present.

The minutes of the last meeting were read and approved.

The President reported the following appointments of Committees:

Committee on Finance: J. I. Kane, Wm. E. Wheelock, M.D.

Committee on Admissions: Cornelius Van Brunt, Jeannette B. Greene, M.D.

Library and Herbarium Committee: Eugene P. Bicknell, Helen M. Ingersoll, Wm. E. Wheelock, M.D., Marie L. Sanial.

Committee on Local Flora.—Phanerogamia: Prof. Thos. C. Porter, N. L. Britton, Ph.D., H. H. Rusby, M.D. Cryptogamia: Prof. L. M. Underwood, Maria O. Le Brun, Smith Ely Jelliffe, M.D.

Committee on Mosses: Mrs. Elizabeth G. Britton.

The regular program was then taken up, being a lecture by Henry A. Siebrecht, entitled "Orchids, their Habitat, Manner of Collecting and Cultivation."

The paper was handsomely illustrated with lantern slides by Mr. Cornelius Van Brunt, colored by Mrs. Van Brunt.

Mr. Siebrecht in his paper referred to the hardships undergone by the orchid-collector, and paid a tribute to the energy displayed by three friends of the speaker, Carmiole, an Italian, who had come to New York when the speaker was a boy; Föstermann, who died about two years ago, the victim, like most collectors, of disease contracted in that enterprise; and Thieme, who had made three trips for Mr. Siebrecht, and who went last to Brazil in search of the *Cattleya autumnalis*, but was never heard from.

Mr. Siebrecht referred also to three trips of his own in quest of orchids, to the West Indies, Venezuela, Brazil and Central America. He then exhibited the lantern views, which were of remarkable beauty and evoked frequent applause. They included numerous representatives of the chief tropical genera cultivated, also with views of interiors showing a house of *Cattleyas* in full blossom, etc. Slides showing numerous species native to the eastern United States followed.

Mr. Siebrecht then described the culture of orchids and classed their diseases, as chiefly because too wet, when the "spot" closes the stomata, or too dry when they collect insects. He referred to their insect enemies at home, the "Jack Spaniard," which eats the marrow from the bulb, and the cattleya-fly, now introduced into English houses. He mentioned the ravages of *Cladosporium*, and the great difficulty with which orchids of the genus *Phalaenopsis* are preserved from fungal diseases.

The subject was further discussed by the President, Dr. Britton, Mr. Samuel Henshaw and Mr. Livingston, the latter referring to his recent experience as an orchid collector. A slide was exhibited, made from a photograph taken by Mr. Livingston, showing his orchids packed upon oxen and so carried down from the mountains to Magdalena.

Mr. Henshaw spoke of his visit to Mr. Siebrecht's nursery in Trinidad, and of the growth made there by *Crotons*, as much in one year as here in four or five. In those gardens they divide their plants by rows and edges of *Crotons* which are sheared off as we would trim a privet-hedge. Mr. Henshaw also paid a deserved tribute to Mrs. Van Brunt for the wonderful success of her coloring of the orchid slides.

WEDNESDAY EVENING, FEBRUARY 24, 1897.

In the absence of the President, Vice-President V. P. Allen presided. There were 28 persons present.

The scientific program was as follows:

1. By Mr. Arthur Hollick, "A fossil *Phragmites* from Staten Island." (Published in this issue of the BULLETIN.)

2. By Mr. E. O. Wooton, "Remarks on some of the rarer Plants of New Mexico."

Mr. Wooton sketched briefly the botanical regions of New Mexico, dividing the territory by differences in the flora into (a) the river valleys, (b) the table-lands or *mesas*, (c) the dry, rocky and narrow mountain ranges, and (d) those areas which are of uniformly high altitude and have numerous mountain ranges closely associated and more or less timbered. He also traced upon a map the routes traversed by most of the botanical collectors who have visited New Mexico, beginning with Pike and including Long, Gregg, Wislizenus in 1846, Emory, Marcy, Sitgreaves and Woodhouse, with the work of the Mexican Boundary and other surveys, 1849 and after. Mr. Wooton was himself practically the first to make collections in the southeast section of the territory, a very interesting botanical region, with high mountains, some of which were illustrated by photographs. Specimens of Mr. Wooton's collecting were then shown, exhibiting about 35 flowering plants and ferns, and including among those familiar in the East: *Pellaea atropurpurea*, *Cystopteris fragilis*, *Pteris aquilina* and *Cheilanthes tomentosa*.

Discussing Mr. Wooton's presentation, Dr. Rusby spoke of his own former travels in New Mexico, and of various incidents of that journey, as of the discovery of *Primula Parryi* on the top of Gray's Peak (central Arizona), blooming on July 3d under three or four inches of snow which had just fallen.

Mr. Rydberg compared some of the features presented by the sand region of Central Nebraska, referring to *Muhlenbergia pungens* and other so-called "blow-out grasses" of the sand-hills, and describing the formation of the characteristic "blow-outs," or hollows, originating in spots where the grasses had died out, and deepening rapidly, sometimes to 300 feet, producing a country where the hills are moving every year, and where he, when camp-

ing, could find no fuel except roots of sand cherries exposed along fresh "blow-outs."

Discussion by Dr. Allen, Mr. Wooton and Dr. Rusby followed relative to the loco-weed poison. Mr. Wooton said that *Spiesia Lamberti* is the chief *loco-weed* about Flagstaff, Arizona, that cattle men claim that the well-fed animal will not touch it, but that those which have formed the taste will not eat anything else. Reasons were urged by the speakers for the belief that the results of the *loco-weed* are due simply to mal-nutrition, or to effect of seeds alone, or to a poison (as extracted by Sheldon) diffused in very minute quantities throughout the plant.

3. By Dr. H. M. Richards "On some of the Reactions of Plants toward Injury."

Dr. Richards spoke on certain effects of wounding upon the functions of various plant organs as shown by his own experiments in Germany last summer. Diagrams illustrating the effect of injury upon both respiration and temperature were shown. In the former case it was seen that the respiration is greatly increased by wounding, attaining its maximum about 24 hours after the injury was inflicted, this increase depending both on the stimulus of the wound itself and upon the access of atmospheric oxygen to the tissues. The occurrence of a corresponding rise in temperature of a local nature, was also briefly referred to, the temperature curve corresponding closely to that described by the increased respiratory activity. The thermoelectric apparatus used was described, its delicacy is such as to indicate a difference of $\frac{1}{400}$ of a degree, the result with potatoes showing a maximum rise of temperature of a little over $\frac{2}{10}$ of a degree at the end of the second day, falling to the end of the fifth day. A remarkable temperature rise in the onion of nearly $3\frac{1}{2}$ degrees was explained by the fact that here the rise was not local, but affected the whole onion in accordance with its morphological structure, and with the fact that metabolism is carried on very fast in the onion.

The paper was discussed by Dr. Jelliffe and by Dr. Britton, especially with regard to the sudden escape of CO_2 after wounding, Dr. Richards considering it to be due largely to contents of intercellular spaces, but partly to solution within the cells; potatoes contain a very considerable amount of enclosed CO_2, a quart

of it being obtained from a pound of potatoes. Dr. Richards distinguished carefully the coincident but independent escape of a slight amount of CO_2 always given off, even in pure hydrogen; to be called "intermolecular respiration."

4. The next paper was a contribution read by title, from Dr. Alexander Zahlbrückner, of Vienna, a corresponding member of the Club, entitled, "Revisio Lobeliacearum Boliviensium hucusque cognitarum." The paper, which is in Latin, enumerates all the species, giving synonomy and references to the literature, and cites collectors and their numbers. There are 39 species, as follows: 9 in *Centropogon*, 2 new; 20 in *Siphocampylos*, 7 new; 1 in *Laurentia;* 2 in *Rhizocephalum;* 3 in *Hypsela;* 4 in *Lobelia.* The paper will be printed in the BULLETIN.

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